Chapter 2
DESCRIPTION OF HMS FISHERIES

2.1 An Introduction to HMS Quotas, Total Allowable Catches, and Discards

Accounting for all sources of fishing mortality is an essential part of managing fisheries for sustainability in the long term. In order to provide the most useful and reliable information for making management decisions, stock assessments should take into account all sources of fishing mortality. In turn, management decisions regarding how many fish can be landed each year should be based upon the recognition that directed fishing mortality is not the only source of mortality for a stock. Generally, a stock assessment is conducted to give managers an estimate of the total level of fishing mortality that a stock can support, usually on an annual basis. This amount is the total allowable catch (TAC), and should include all sources of fishing mortality. Under this FMP, NMFS intends to work both domestically and internationally to establish landings quotas and discards as separate portions of the TAC. Currently, stock assessments for Atlantic tunas, swordfish, and sharks include dead discards in their calculations, although discards are treated differently in establishing landings quotas for these three species groups.

There are three basic approaches that are used to develop quotas for HMS based on the total allowable catch (TAC). Under the first approach, the TAC is divided into a landings quota and a discard allowance, each of which is allocated among fishing nations and/or user groups. NMFS then implements U.S. landings quotas and the discard allowance, and tracks landings and discards through in-season monitoring, closing fisheries as necessary to keep within the quotas. The west Atlantic bluefin tuna quota is now managed under this approach, with a dead discard allowance and landings quota, rather than a total quota.

The second approach is to calculate the TAC, subtract the estimated dead discards (from all fishing nations and/or user groups) and establish a landings quota, allocating only shares of the landings quota to each fishing nation and/or user group. An example of this approach is the Atlantic shark fishery. NMFS subtracts dead discards and state landings after Federal closures from quotas when adjusting the commercial quota for sharks to account adequately for all sources of fishing mortality. Due to the delay in obtaining data for dead discards and landings before a closure, this adjustment is made at the beginning of each fishing year based on the previous year’s dead discards and state landings.

The third approach, which was used to manage all HMS quotas except bluefin tuna prior to implementation of this FMP, is to account for all sources of mortality (e.g., directed and incidental) in the stock assessment, but to interpret the TAC as a “landings” quota. NMFS rejects the third approach and will account for dead discards in the Atlantic swordfish fishery using either of the first two methods, pending ICCAT approval.

2.2 Atlantic Tunas

2.2.1 Life History and Status of the Stocks: Atlantic Tunas

Tunas and mackerel are members of the family Scombridae in the suborder Scombroidei, which they share with swordfish (family Xiphiidae) and billfishes (family Istiophoridae). Atlantic tunas are wide-ranging in size; tunas in this management plan include the skipjack tuna (*Katsuwonus pelamis*) which is less than one meter (18 kg) as an adult, and the giant bluefin tuna (*Thunnus thynnus*) which can grow to more than three meters in length (675 kg or 1485 lbs) (Collette and Nauen, 1983). The Atlantic tunas include some of the largest and fastest predators in the oceans, and their physiological adaptations reflect that role in the ocean's ecosystems. Tuna have among the highest metabolic rates, fastest digestion rates, and the most extreme specializations for sustained levels of rapid locomotion of any fish (Helfman *et al*,1997).

Many of these characteristics are common among HMS. The tunas' body shape, round or slightly compressed in cross section, minimizes drag as they move through the water. Their lunate tails are deeply forked. These adaptations for speed are further enhanced by depressions on the body surface which are shaped to hold the fins in a streamlined position. Small dorsal and ventral finlets minimize turbulence and allow the tail to propel the fish forward more efficiently. Tunas utilize a respiratory mode known as ram gill ventilation, which differs from the more common mechanism whereby water is actively pumped across the gills. Ram gill ventilation requires that the fish swim continuously with its mouth open to maintain water flow across the gill surfaces. It is believed that this system helps conserve energy for voracious fishes like the tunas (Helfman *et al*., 1997).

Tunas are endothermic, with a physiological mechanism to control their body temperature. These fishes maintain an elevated body temperature by conserving the heat generated by active swimming muscles. This enables tunas to dive into colder and deeper water, giving them an edge in overtaking their prey. Heat conservation is accomplished through an adaptation of the circulatory system. The internal temperatures of these fishes remains fairly stable even as they move from surface waters to colder deep water. Bluefin tuna keep muscle temperatures between 28° and 33°C while swimming through waters ranging from 7° to 30°C, while yellowfin and skipjack tunas maintain muscle temperatures at about 3°C or 4° to 7°C above ambient water temperatures, respectively.

Tunas move thousands of kilometers annually throughout the world's tropical, subtropical, and temperate oceans and adjacent seas, primarily in the upper 100 to 200 meters of open ocean. As adults and juveniles, they feed on a variety of fishes, cephalopods, and crustaceans, depending on seasonal prey availability. The foraging and movement patterns of tunas reflect the distribution and scarcity of appropriate prey in the open seas; these fishes must cover vast expanses of the ocean in search of sufficient food resources. Consequently, aggregations of tunas are often correlated with areas where higher densities of prey are found, such as current boundaries, convergence zones, and upwelling areas (Helfman *et al*., 1997). Additional information on the life history and habitat of tuna species in the management unit can be found in Chapter 6, HMS Essential Fish Habitat Provisions.

Bluefin Tuna

In west Atlantic waters, bluefin tuna reach maturity at about 196 cm (77 inches) straight fork length, and 145 kg (320 lbs). Bluefin tuna of this size are believed to be about eight years old. Stock assessments assume that the spawning population consists of all bluefin tuna eight years and older. Although each spawning Atlantic bluefin tuna produces approximately 30 million eggs, natural mortality on juvenile bluefin tuna is high (National Research Council, 1994). Bluefin tuna in the west Atlantic grow more slowly, generally reach a larger maximum size, and mature at an older age compared to bluefin tuna caught in the east Atlantic, where they are believed to first spawn at age five (SCRS, 1997). This high age at maturity for west Atlantic bluefin tuna means that when the spawning stock has been reduced, it can take many years for it to rebuild, even with drastic reductions in fishing mortality.

Bluefin tuna have a relatively long life span (20 years or more), which means that the stock consists of several age classes, a condition that serves as a buffer against adverse environmental conditions and that confers some degree of stability on the stock. As opportunistic feeders that can migrate long distances in search of prey, bluefin tuna may also be quite resilient to fluctuations in prey concentrations, although changes in prey availability may greatly influence fishing patterns. Bluefin tuna are distributed from the Gulf of Mexico to Newfoundland in the west Atlantic, from roughly the Canary Islands to south of Iceland in the east Atlantic, and throughout the Mediterranean Sea. Bluefin tuna spend a large part of the year feeding in temperate waters, returning to the warm waters of the Gulf of Mexico to spawn (Helfman *et al*., 1997). Trans-Atlantic migrations are well-documented, although migration patterns and their significance to species life history are unknown.

ICCAT's Standing Committee on Research and Statistics (SCRS) was unable to arrive at a consensus as to which stock-recruitment assumption might better reflect the population dynamics of west Atlantic bluefin. As described above, the two models result in widely disparate estimates of maximum sustainable yield (MSY) and other parameters. An alternative to using one model over another would be to combine the results from both models, weighting each equally. Using this combined approach, F_{MSY} is 0.173, and F_{97} is 0.31, resulting in $F_{97}/F_{MSY} = 2.38$. For this combined model, maximum sustainable yield is estimated to be 3,400 mt, and current spawning stock biomass (SSB) is estimated to be at approximately 31 percent of levels necessary to produce maximum sustainable yield. Current spawning stock biomass is estimated to be 16 percent of 1975 levels, which had been used as a proxy for SSB_{MSY} in past stock assessments. Using this combined model, the west Atlantic total allowable catch would have to be reduced to below 2,000 mt in order for the stock to rebuild to a level which would support maximum sustainable yield in 20 years.

Over the past decade there has been contentious debate in scientific and fishing communities about the stock structure of Atlantic bluefin tuna. ICCAT currently manages bluefin based on a two-stock hypothesis, with the two management units separated at 45° W above 10° N and at 25° W below the equator, with an eastward shift in the boundary between those parallels. The initial basis for the management units was primarily the existence of separate spawning areas in the Gulf of Mexico and the Mediterranean Sea.

Additional evidence supporting the two-stock hypothesis included: 1) coastal abundance of juveniles on each side of the ocean; 2) the high proportion of juvenile bluefin tagged on one side of the Atlantic and at liberty for at least a year that were recaptured on the same side of the ocean; and 3) relatively low catch rates by high seas longline vessels in the central Atlantic. This is also the most conservative assumption in the face of uncertain genetic evidence.

Because there is uncertainty regarding the two-stock hypothesis, SCRS carries out biomass projections with sensitivity analyses to account for different potential levels of mixing. However, at the present time, the working hypothesis of two stocks remains the best available science, for both stock assessments and bluefin tuna management. In its 1998 report, SCRS acknowledges that while bluefin tuna stock assessments are based on the assumption of two distinct stocks, "recent tagging information suggests that migratory behavior may be complex" and that "even minor mixing could, in principle, have a marked effect on stock assessments based on two distinct stock assumptions, due to the difference in population size between the two stocks." SCRS has, in fact, investigated mixing assuming a variety of migratory behaviors, the results of which have been "either more optimistic or pessimistic, depending on the model forms used." SCRS concluded that mixing models and the available data are not yet considered sufficient to provide reliable prediction", but "nevertheless, the Committee believes that assessments assuming no mixing should be reasonably robust, if adequate management approaches are applied to both the eastern and western management units." (SCRS, 1998).

The latest stock assessment for west Atlantic bluefin tuna (1998) estimates F_{MSY} at a level of 0.078 (Beverton-Holt stock-recruitment model) or 0.173 (two-line stock-recruitment model). The corresponding fishing mortality rate in 1997 was .300 (two-line) or .320 (Beverton-Holt), resulting in F_{97}/F_{MSY} = 1.73 or F_{97}/F_{MSY} = 4.10, respectively. The 1998 assessment showed that spawning stock biomass has increased slightly to about 14 to 17 percent of 1975 levels, which had been the spawning stock biomass level used as a proxy for SSB_{MSY}. The 1998 assessment did estimate SSB_{MSY} for the two stock-recruitment models. Using the two-line model, maximum sustainable yield is estimated to be 2,800 mt, and current spawning stock biomass is estimated to be at approximately 48 percent of levels necessary to produce maximum sustainable yield. The two-line model assumes that recruitment will not increase with spawning stock biomass. Using the Beverton-Holt model, maximum sustainable yield is estimated to be 7,700 mt, and the current spawning stock biomass is estimated to be at approximately seven percent of levels necessary to produce maximum sustainable yield. This model indicates higher chances of good recruitment as spawning stock biomass increases.

Some constituents have contended, based on regular and extensive experience with the resource, that the bluefin tuna stock is much larger and healthier than stock assessments indicate. Again, current stock assessments provide the best available science and must be used as the basis for management decisions. However, NMFS will continue to fund scientific studies on stock size, migration, spawning age and behavior of Atlantic bluefin tuna to investigate these challenges. Results of such studies are taken into consideration and become part of the spectrum of information on which NMFS bases conservation and management decisions. The framework provisions of this FMP allow for future modifications of quotas and rebuilding periods to incorporate results of new stock assessments and ICCAT negotiations.

Bigeye Tuna

Atlantic bigeye tuna (*Thunnus obesus*) are widely distributed in tropical and temperate waters between 45° N and 45° S latitudes. Young bigeye tuna form schools near the sea surface, mixing with other tuna such as yellowfin and skipjack tunas (Collette and Nauen, 1983). Bigeye tuna reach sexual maturity at about four years of age, at which point they are approximately 100 cm long (40 inches). They spawn throughout the year in tropical waters from 15° N to 15° S. Catch information from the surface fisheries indicates that the Gulf of Guinea is a major nursery ground for the species. ICCAT recognizes a single Atlantic stock for management purposes, although the possibility of other scenarios, such as north and south Atlantic stocks, should not be disregarded (SCRS, 1997).

The maximum sustainable yield for bigeye tuna is estimated to be between 70,000 mt and 90,000 mt. The most recent assessment suggests that current F estimates surpass F_{MSY} by 50 to 120 percent while the biomass of bigeye tuna in 1997 (B_{1997}) is somewhere between 60 and 80 percent of B_{MSY}, with the stock declining. Biomass is likely to decline further if fishing mortality rates continue to exceed F_{MSY}. Except for 1997, annual bigeye tuna landings have been near or greater than 100,000 mt since 1993, while the replacement yield is estimated to be between 60,000 and 80,000 mt (SCRS, 1998). SCRS estimates that maintaining the current exploitation pattern would result in reductions in yield to levels below maximum sustainable yield in the near future. In 1998, ICCAT requested that SCRS develop rebuilding scenarios for bigeye tuna.

ICCAT has described bigeye tuna as fully-exploited and has expressed concern about recent increases in landings, particularly of small fish. Recovery trajectories for Atlantic bigeye tuna are constrained by their life history strategies and international fishing efforts. Bigeye tuna have a broad distribution range in the Atlantic Ocean between 50° N and 45° S latitudes. Current estimates of bigeye tuna catches in the United States indicate that U.S. landings are approximately one percent of the reported catch of bigeye tuna in the Atlantic Ocean; thus, the international component of this fishery will complicate rebuilding of the stock.

Albacore Tuna

Albacore tuna (*Thunnus alalunga*) are widely distributed throughout temperate waters of the Atlantic Ocean and the Mediterranean Sea, ranging from 50° N to 40° S latitudes. Aggregations are composed of similarly sized individuals, with those groups made up of the largest individuals making the longest journeys. Groups may include other tuna species, such as skipjack, yellowfin, and bluefin. They reach maximum sizes of about 125 cm (50 inches) and maximum weights of about 40 kg (88 lbs). Atlantic albacore tuna are considered mature at the age of five years, corresponding to approximately 90 cm (35 inches) (SCRS, 1998). Albacore tuna spawn in the spring and summer in tropical waters of the Atlantic (ICCAT, 1997). Larvae are also found in the Mediterranean Sea and historically in the Black Sea (Vodyanitsky and Kazanovak, 1954).

For assessment purposes, the existence of three stocks is assumed: north and south Atlantic stocks (separated at 5° N) and a Mediterranean stock. The SCRS conducted stock assessments for north and south Atlantic stocks in 1998; the results were consistent with the results of previous assessments. The SCRS has not reached a definitive conclusion regarding the outlook for the south Atlantic albacore tuna stock, although the current level of exploitation appears to be sustainable.

Equilibrium yield analyses indicated that the current fishing mortality rate on the north Atlantic stock may be about 25 percent higher than that which would support the maximum sustainable yield, and an alternative assessment model indicated that the current F may be 40 percent higher than that which would support the maximum sustainable yield (SCRS, 1998). Although north Atlantic albacore was not listed by NMFS as overfished in the 1998 Report to Congress, this species meets the status determination criteria adopted in this FMP. NMFS will analyze rebuilding alternatives for north Atlantic albacore in an amendment to this FMP, which will establish the foundation that can be used to develop an international ebuilding plan. Due to the small U.S. share of this international fishery, rebuilding will require a multi-lateral approach. The first step in establishing the foundation for an international rebuilding program is to ask SCRS to develop recovery scenarios for the stock.

Yellowfin Tuna

Yellowfin tuna (*Thunnus albacares*) are fast-growing, reaching sexual maturity at a size of about 25 kg (55 lbs) and 110 cm (44 inches), corresponding to an age of about three years (SCRS, 1997). The maximum size of yellowfin tuna is over 200 cm fork length (Collette and Nauen, 1983). In the Atlantic, the greatest concentrations are found within 15° north or south of the equator. Yellowfin tuna may be found seasonally as far north and south as the northeastern United States and Uruguay, with substantial concentrations occurring in the Gulf of Mexico during spring and summer months. Their distribution is determined by water temperature and the availability of prey species such as pelagic fishes and squids. Yellowfin tuna is a schooling species, with juveniles found in schools at the surface mixing with skipjack and bigeye tuna. Larger fish are found in deeper water and also extend their ranges into higher latitudes than smaller individuals. The main spawning ground in the Atlantic Ocean is the Gulf of Guinea near the equator, with spawning occurring from January to April

(SCRS, 1998). Individual fish may spawn repeatedly during a single spawning season. All individuals in the Atlantic probably comprise a single population, but movement patterns are not well known (SCRS, 1997).

The most recent SCRS stock assessment estimates that the current (1997) fishing mortality rate may be close to the level of F_{max} (above or below depending on the model used). Production model analyses imply that although yellowfin tuna catches are slightly lower than equilibrium MSY levels, effort may be either above or below the MSY levels. A number of different production model analyses were used to account for the relationship of catch and effort in recent years to the equilibrium MSY and effort levels. Under a scenario of a 3% annual increase in efficiency, current effort is somewhat below the MSY level, whereas under a scenario of a five-percent annual increase in efficiency, it is somewhat above the MSY level. VPA analyses indicate that spawning stock biomass decreased in the early to mid-eighties, had recovered by 1990 due to reduced fishing mortality rates and somewhat higher recruitment, but has subsequently declined back to levels similar to those of the mid-1980s. Although absolute numbers vary, the four VPA scenarios show very consistent relative trends. Trends in fishing mortalities in recent years are less reliable due to estimation problems common to all methods used.

The SCRS concluded that the current fishing mortality rate for yellowfin is probably greater than that which would support MSY (SCRS, 1998). Therefore, it is critical to ensure that effective fishing effort does not increase further. NMFS is concerned about the status of yellowfin tuna and the need to ensure consistency with the ICCAT recommendation to limit the effective level of fishing effort. Yellowfin tuna is not considered overfished at this time. However, NMFS will update the status of yellowfin tuna relative to the status determination criteria in the FMP as new scientific information becomes available.

Skipjack Tuna

Skipjack tuna (*Katsuwonus pelamis*) are found throughout tropical and warm-temperate seas. Skipjack is a schooling species, forming aggregations associated with hydrographic fronts (Collette and Nauen, 1983). Skipjack tuna spawn opportunistically throughout the year in vast areas of the Atlantic Ocean. The size at first maturity is about 45 cm (18 inches), slightly smaller for females, which corresponds to about one to one and a half years of age (SCRS, 1997).

The stock structure of Atlantic skipjack tuna is not well known, and two management units (east and west) have been established due to the development of fisheries on both sides of the Atlantic and to the lack of transatlantic recoveries of tagged skipjack tuna. Spawning stock biomass relative to B_{MSY} and fishing mortality rates relative to F_{MSY} are currently unknown. The 1997 SCRS report states that given characteristics of this species such as short life span, rapid growth, and high natural mortality, the current levels of exploitation can probably be maintained. However, with changes occurring in the east Atlantic purse seine fisheries, skipjack tuna fisheries should be carefully monitored (SCRS, 1996b). SCRS plans to conduct the first stock assessment for west Atlantic skipjack tuna in 1999.

2.2.2 International Aspects of the Atlantic Tuna Fishery

Bluefin Tuna

Peak yields of bluefin tuna from the west Atlantic (about 8,000 to 19,000 mt) occurred between 1963 and 1966 when much of the catch was taken by Asian longline vessels off Brazil. During the late 1960s and 1970s, yields averaged about 5,000 mt. By 1973, the United States and other nations began to express concern about the decrease in the abundance of bluefin tuna. In response to this concern, ICCAT recommended a minimum size limit in 1974. After conducting a series of stock assessments, SCRS recommended in 1981 that catches of west Atlantic bluefin tuna be reduced to as near zero as possible to stop the decline of the stock. Based on this recommendation, a scientific monitoring quota of 1,160 mt was adopted in 1982. The catch limit was increased to 2,660 mt in 1983, and was maintained at that level through 1991.

At the 1991 meeting, ICCAT recommended additional measures to prevent further declines in the west Atlantic bluefin tuna stock, including a ten percent reduction in the total allowable catch. In 1993, the west Atlantic bluefin tuna quota was reduced further from 2,394 mt in 1993 to 1,995 mt in 1994 and 1,200 mt in 1995. The SCRS projections in 1994 indicated that the stock could support higher quota levels and still begin to rebuild, albeit more slowly. Based on the new stock assessment, ICCAT members adopted a recommendation to increase the annual bluefin tuna total allowable catch in the west Atlantic Ocean from 1,995 mt to 2,200 mt. The share allocated to the United States was set at 1,311 mt. At the 1996 meeting, ICCAT recommended an annual west Atlantic bluefin tuna total allowable catch of 2,354 mt for 1997 and 1998. The annual quota allocated to the United States for 1997 and 1998 was 1,344 mt, an increase of 33 mt over the 1995 and 1996 levels.

Based on the 1998 stock assessment, ICCAT adopted a Rebuilding Program for west Atlantic bluefin tuna with the goal of reaching stock levels to support maximum sustainable yield in 20 years. The annual west Atlantic bluefin tuna total allowable catch of 2500 mt is shared among the United States, Japan, Canada, the United Kingdom territory of Bermuda, and the French territories of St. Pierre and Miquelon (Table 2.1). The landings quota allocated to the United States was increased by 43 mt from 1,344 mt to 1,387 mt, to apply annually. The U.S. allowance for dead discards is an additional 68 mt. If there are dead discards in excess of this allowance, they must be counted against the following year's quota. If there are fewer dead discards, then half of the underharvest may be added to the following year's quota while the other half is conserved. The recommendation also allows four years to balance the eight percent tolerance for bluefin tuna under 115 cm (young school and school bluefin tuna). The Rebuilding Program provides flexibility to alter the total allowable catch, the maximum sustainable yield target, and/or the rebuilding period based on subsequent scientific advice. However, the annual total allowable catch of 2,500 mt will not be altered unless there is evidence that a catch level greater than 2,700 mt or less than 2,300 mt would have at least a 50 percent probability of rebuilding the stock to maximum sustainable yield within the 20-year time frame.

The dramatic increase in total bluefin tuna catches in 1994, 1995, and 1996 was due to increases in the catch from the east Atlantic stock. A variety of vessel types participate in the east Atlantic bluefin tuna fisheries, with landing sites located in many countries (Table 2.2). In 1996, highest catches were reported from baitboat, longline and traps in the east Atlantic, and primarily from purse seine and longline vessels in the Mediterranean. French purse seine activity in the Mediterranean has increased significantly in recent years, and the number of large longline vessels, some of which do not identify themselves as fishing for any particular nation, has also increased dramatically. This fishery has developed largely in response to strong market demand from the Japanese market. Baitboats are responsible for large catches of small fish ages one to three in the Bay of Biscay, in part due to the Spanish albacore tuna fleet redirecting effort toward east Atlantic bluefin tuna during the months of June and July. Japanese longliners have been exploiting a new fishing zone in the north Atlantic Ocean around 60° N and 20° W, in addition to the traditional sectors.

The SCRS projections indicate that current catch levels of bluefin tuna in the east Atlantic and Mediterranean are not sustainable. Although ICCAT recommended in 1974 that fishing mortality on bluefin tuna should not increase, this recommendation was not successful in limiting catches in the east Atlantic and Mediterranean. ICCAT has since adopted additional management measures for the east Atlantic and Mediterranean bluefin tuna fisheries. In 1998, ICCAT adopted a fixed total allowable catch and quotas for each member fishing in the east Atlantic and Mediterranean bluefin tuna fishery. Pursuant to ICCAT compliance measures, the 1999 quotas will be reduced to account for quota overages in 1997. These quotas represent a significant reduction from recent catch levels that are well in excess of the sustainable yield. The SCRS has noted that the condition of the east Atlantic stock and fishery could adversely affect recovery of the bluefin tuna stock in the west Atlantic.

Table 2.1 Reported catches of west Atlantic bluefin tuna, 1997. (SCRS, 1998)

Country	**1997 Catch (mt ww)**	**Percent of West Atlantic Catch**
United States (landings)	1,331*	61%
United States (dead discards)	51	
Canada (landings)	503	23%
Canada (dead discards)	6	
Japan	329	15%
United Kingdom-Bermuda	2	1%
TOTAL (All Countries)	**2,208**	**100%**

* The draft HMS FMP showed preliminary 1997 landings as 1,317 mt, the amount reported to ICCAT in August 1998.

Table 2.2 Reported catches of east Atlantic and Mediterranean bluefin tuna, 1997. (SCRS, 1998)

Country	**1997 Catch (mt ww)**	**Percent of East Atlantic-Mediterranean Catch**
Italy	9,548	23%
France	8,470	21%

Spain	8,047	20%
Japan	3,198	8%
Morocco	2,603	6%
Tunisia	2,200	5%
Croatia	1,105	3%
Other Countries *	3,446	8%
Unreported Catch	2,636	6%
TOTAL (All Countries)	**41,253**	**100%**

* Other countries catching less than 1000 mt of bluefin the east Atlantic and Mediterranean in 1997 include Portugal, Korea, Greece, Chinese-Taipei, Turkey, Malta, Algeria, Libya and the People's Republic of China.

Bigeye Tuna

Bigeye tuna is a primary target species for many longline and baitboat fisheries in the tropical waters of the Atlantic (Table 2.3). Japan and Chinese-Taipei (Taiwan) are responsible for more than half of Atlantic-wide bigeye tuna longline catches by weight. Their catch is comprised primarily of medium to large bigeye tuna. Major baitboat fisheries targeting small to medium bigeye tuna are located near Ghana, Senegal, the Canary Islands, Madeira, and the Azores. Tropical purse seine fleets catch small bigeye tuna in the Gulf of Guinea and off Senegal in the east Atlantic, and off Venezuela in the west Atlantic. Total Atlantic bigeye tuna catch has increased substantially since 1990. ICCAT has not recommended Atlantic-wide quotas for bigeye tuna. However, in 1998, ICCAT adopted two new management recommendations that are designed to limit effort in commercial fisheries for bigeye tuna throughout the Atlantic. ICCAT also adopted a resolution in 1998 that tasks SCRS with developing stock rebuilding scenarios for bigeye.

Although ICCAT adopted a minimum size of 3.2 kg for bigeye tuna in 1979, a large number of undersized fish is still harvested by the surface fleets operating near the equator. SCRS estimates that approximately 70 percent by number of bigeye tuna landed are smaller than the minimum size, well in excess of the 15 percent tolerance. Purse seine fleets in the east Atlantic have developed a fishery that targets schools of tuna near artificial floating objects. These objects are also known as fish aggregating devices (FADs). This method of fishing has increased harvesting efficiency and contributed to excessive catch of undersized bigeye tuna. Favorable oceanographic conditions as well as the extensive use of sonar and deeper nets have also contributed to increased bigeye tuna harvest in recent years. In 1998, ICCAT established a mandatory time/area closure for purse seiners using fish aggregating devices in equatorial waters.

Table 2.3 Reported catches of Atlantic bigeye tuna, 1997. (SCRS, 1998)

Country	**1997 Catch (mt ww)**	**Percent of Atlantic-wide Catch**
Japan	27,427	31%
Chinese-Taipei	19,242	22%

Spain	13,386	15%
Ghana	7,431	8%
France	6,050	7%
Portugal	5,437	6%
Brazil	1,237	1%
United States	1,095	1%
Other Countries	2,454	3%
Not Reported	5,800	6%
TOTAL (All Countries)	**89,559**	**100%**

Albacore Tuna

The primary nations targeting albacore tuna in the north Atlantic include Spain, France, and Chinese-Taipei (Table 2.4). The historical surface fisheries for albacore tuna in the north Atlantic include Spanish trolling in the Bay of Biscay as well as Spanish and Portuguese baitboats in the Bay of Biscay and near the Azores. Vessels from Chinese-Taipei target large albacore tuna with longline vessels in deeper waters of the central and western north Atlantic. Smaller albacore tuna are caught primarily by surface fishing gears such as driftnets and pelagic pair trawls. Ireland joined the driftnet fishery in the early 1990s. Although albacore tuna harvests in the north Atlantic have declined since 1970, catch and effort in newer surface fisheries have increased since 1987. SCRS has determined that north Atlantic albacore tuna is at or near a level of full exploitation. In 1998, ICCAT adopted a recommendation to limit fishing capacity to the number of vessels in the directed albacore tuna fishery during the years of 1993 to 1995.

Traditionally, south Atlantic albacore tuna was exploited primarily by a South African surface baitboat fishery off the west coast of South Africa. However, South African catch decreased in 1996 and other countries including Namibia, Japan, Taiwan, and Brazil are now major players in the fishery. Catch data indicate that small fish are making up an increasing share of albacore tuna harvested in the south Atlantic. Although current catch levels appear to be sustainable, ICCAT has established a catch limit that will be implemented via existing cooperative arrangements among harvesting nations.

Table 2.4 Reported catches of north Atlantic albacore tuna, 1997. (SCRS, 1998)

Country	1997 Catch (mt ww)	Percent of North Atlantic Catch
Spain	17,264	63%
France	4,618	17%
Chinese-Taipei	3,330	12%
Ireland	874	3%
Portugal	395	1%
United States	339	1%
Japan	325	1%
Venezuela	309	1%
Other Countries	72	< 1%
TOTAL (All Countries)	**27,526**	**100%**

Yellowfin Tuna

Yellowfin tuna are harvested by many nations between 45° N and 40° S using surface gears including purse seine, baitboat, troll and handline, and sub-surface gears such as longline (Table 2.5). Purse seines are responsible for 80 percent of yellowfin tuna catch in the east Atlantic. The French and Spanish purse seine fishery developed rapidly in the 1970s, extending from coastal waters to the high seas especially in yellowfin tuna spawning areas around the Equator. In coastal areas, purse seines are very efficient in catching a wide range of sizes, including juveniles in these mixed schools. Longline catches of yellowfin tuna are primarily incidental in the east Atlantic. The baitboat fishery, which has declined in importance in recent years, has always targeted juvenile yellowfin tuna in coastal waters, together with juvenile bigeye tuna and some smaller tuna. These baitboat fisheries are still active in the waters off Senegal, Ghana, the Canary Islands, Cape Verde, Madeira, Venezuela, and Brazil.

ICCAT has expressed concern over the high proportion of juvenile yellowfin tuna that are landed. In 1995, an estimated 50 percent by number of yellowfin tuna landed were less than the minimum size of 3.2 kg, although the specified tolerance level is only 15 percent (SCRS, 1997). As in the bigeye tuna fisheries, these high catches of juveniles are largely a result of the use of fish aggregating devices. Atlantic yellowfin tuna landings reached a record high in 1990, primarily due to increased landings in the east Atlantic. Since 1990, catches across the Atlantic have declined somewhat and then remained stable. In 1993, ICCAT recommended that there be no increase in the level of effective fishing effort over 1992 levels.

Table 2.5 Reported catches of Atlantic yellowfin tuna, 1997. (SCRS, 1998)

Country	**1997 Catch (mt ww)**	**Percent of Atlantic-wide Catch**
France	29,828	23%
Spain	25,301	19%
Ghana	18,377	14%
Venezuela	14,689	11%
United States	7,625	6%
Chinese-Taipei	4,466	3%
Russia	4,275	3%
Japan	3,565	3%
Brazil	2,705	2%
Other Countries	5,618	4%
Not Reported	14,355	11%
TOTAL (All Countries)	**130,804**	**100%**

Skipjack Tuna

The stock structure of Atlantic skipjack tuna is uncertain; separate management units are maintained in the east and west Atlantic. Skipjack tuna fisheries have changed significantly since 1991, with the introduction of fishing on floating objects and the expansion of the purse seine fishery towards the west Atlantic and closer to the equator. The use of fish aggregating devices has directed effort into new areas, extending the fishing grounds westward to 30° west and south of the equator.

Skipjack tuna are harvested almost exclusively by surface gears. The west Atlantic fishery for skipjack tuna is dominated by the Brazilian baitboat fishery (Table 2.6). Venezuelan purse seiners participate in the west Atlantic to a lesser extent. A declining trend in skipjack tuna landings has been observed in the east Atlantic since 1993. The most important fisheries are the purse seine fisheries, especially those of Spain and France. Other purse seine fleets that harvest skipjack tuna include Vanuatu, Malta, Morocco, Ghana, Netherlands Antilles, Panama, and St. Vincent. Skipjack tuna are also harvested by the baitboat fisheries of Ghana, Spain, and Portugal. A minor amount is taken as secondary target catch on longline vessels. SCRS has noted that additional research on skipjack tuna is needed.

Table 2.6 Reported catches of west Atlantic skipjack tuna, 1997. (SCRS, 1998)

Country	**1997 catch (mt ww)**	**Percent of West Atlantic Catch**
Brazil	26,564	84%
Venezuela	3,676	12%
Cuba	1,000	3%
Dominican Republic	146	< 1%
United States	69	< 1%
TOTAL (All Countries)	**31,455**	**100%**

2.2.3 Domestic Aspects of the Atlantic Tuna Fishery

Bigeye, albacore, yellowfin, and skipjack (BAYS) tunas, as well as bluefin tuna have been exploited in the west Atlantic for many years. In the early 1900s, a sport fishery developed for small and medium tunas off New York and New Jersey, and for giant bluefin tuna in the Gulf of Maine. The rod and reel fishery expanded rapidly during the 1950s and 1960s, as hundreds of private, charter, and partyboats targeted tunas along the mid-Atlantic coast. This recreational fishery continues today from Cape Hatteras to the Canadian border. In addition, it is locally important in the Straits of Florida. Occasional sport catches are also made in the Gulf of Mexico.

Until the late 1950s, the U.S. commercial fishery for tunas employed mostly harpoons, handlines, and traps. There was no commercial market for bluefin tuna, and giant bluefin tuna (greater than 310 lbs) were regarded as a nuisance because of the damage they caused to fishing gear. Much of the bluefin tuna catch was incidental to operations targeting other species. In 1958, commercial purse seining for Atlantic tunas began with a single vessel in Cape Cod Bay and expanded rapidly into the region between Cape Hatteras and Cape Cod during the early 1960s. The purse seine fishery between Cape Hatteras and Cape Cod was directed mainly at small and medium bluefin tuna, and at skipjack tuna, all for the canning industry. North of Cape Cod, purse seining was directed at giant bluefin tuna. A pelagic longline fishery for Atlantic tunas also developed rapidly during the 1960s, comprised mainly of Japanese vessels fishing in the Gulf of Mexico.

High catches of juvenile bluefin tuna were sustained throughout the 1960s and into the early 1970s. These high catch rates by U.S. purse seine and longline vessels, along with the intense longline fishery pursued by Japanese vessels in the 1970s, are believed to be responsible for the decline in abundance during subsequent years. In the late 1970s, approximately 10,000 giant bluefin tuna were taken in one year alone out of the Gulf of Mexico. An international market developed for giant bluefin tuna, with fresh bluefin tuna flown directly to Japan for processing into sushi or sashimi. By the late 1980s, high ex-vessel prices and the increased importance of the Japanese market had blurred the distinction between the sport and recreational fisheries for bluefin tuna and much of the traditionally recreational catch for medium and giant bluefin tuna was being sold for shipment to Japan.

In 1992, NMFS responded by banning the sale of school, large school, and small medium bluefin tuna (27 inches to less than 73 inches curved fork length).

In the United States, Atlantic tuna permits are currently issued in seven categories. The commercial categories are: General, Angling, Charter/Headboat, Harpoon, Purse Seine, Longline and Trap. Directed fisheries for Atlantic tuna are limited by regulation to the following gear types: rod and reel, handline, harpoon, bandit gear, and purse seine nets. Limited incidental catches of bluefin tuna are allowed for vessels fishing with longlines, purse seine nets, fixed gear, and traps. Although a control date for the Atlantic tuna fisheries was published on September 1, 1994, the number of new permit applicants continues to rise. As of October 31, 1998, there were 20,194 vessels permitted to participate in the Atlantic tuna fisheries, including 7,096 General category vessels; 10,668 Angling category vessels; 2,047 Charter/Headboat category vessels; 319 Incidental category vessels; 59 Harpoon category vessels; and five Purse Seine category vessels. U.S. landings of Atlantic tunas by species are provided in tables 2.11 through 2.15.

In 1992, NMFS established base quotas for each permit category in the bluefin tuna fishery based upon the historical share of catch in each of these categories during the period 1983 to 1991. These quotas were used in 1992, 1993, and 1994, with overharvests and underharvests added and subtracted as required by ICCAT, as well as some inseason transfers. The quotas were modified in 1995 when the Purse Seine category quota was reduced by 51 mt. Baseline domestic quota allocations in 1998 remained the same as in 1995, with some adjustments. This allocation reflects recent trends in fleet size, effort and landings by category, as well as the ICCAT recommendation which specifies that data should be collected for broadest range of size-classes possible, given size restrictions. Under ATCA, no regulation may have the effect of increasing or decreasing the ICCAT-recommended quota for the United States. It should be noted that foreign fishing for Atlantic tunas is not authorized in the U.S. Exclusive Economic Zone (EEZ)

The U.S. handgear fishery for Atlantic tunas is mainly a summer and fall fishery. The recreational fishery for bluefin tuna takes place mainly in the mid-Atlantic region and targets bluefin tuna between 27 and 73 inches in length. Private vessels targeting these fish are permitted in the Angling category, while the charter/headboats targeting these fish are permitted in the Charter/Headboat category. Many fishermen who might normally call themselves “recreational” participate in the General category in New England waters during the summer and fall; General category permit holders may sell bluefin tuna greater than 73 inches. A 1998 regulation prohibiting the retention of bluefin tuna less than 73 inches by fishermen in the General category clarified the distinction between the commercial and recreational fisheries. The commercial handgear fishery for bluefin tuna occurs mainly in New England, with vessels targeting fish using handline, rod and reel, and harpoon. Table 2.7 summarizes the traditional gear, area, size of fish, and seasonality of the domestic bluefin tuna fishery. Table 2.11 presents domestic Atlantic bluefin tuna landings, by category for the years 1983 to 1998. Tables 2.12 to 2.15 present 1995 to 1997 domestic landings by area and gear type for bigeye, albacore, yellowfin, and skipjack tunas, respectively.

In most years, bluefin tuna first appear along the U.S. Atlantic coast (not including the spawning areas in the Gulf of Mexico) off the Virginia Capes in late May or early June. Fishing for smaller bluefin tuna with rod and reel generally begins in early summer off Virginia, and the center of recreational activity moves northward into the New York Bight as the season progresses. Fishing usually takes place between eight to 200 km from shore. Occasionally, concentrations of larger bluefin tuna in “hot spots” appear off the mid-Atlantic coast during June and July as these fish migrate north to their summer feeding grounds off New England, where they are targeted by the commercial sector.

Recently, a recreational fishery has developed off the coast of North Carolina as concentrations of large bluefin tuna began appearing from January through March. Catch rates in 1996 and 1997 were extremely high as compared to catch rates off the New England coast. Many bluefin tuna were tagged off North Carolina in 1996 and 1997, using the latest technology, such as pop-up and archival satellite tags. Catch rates in 1998 were low, possibly due to oceanographic conditions resulting from the 1998 El Niño event. In contrast, 1999 catch rates have once again been high, and additional bluefin tuna have been released with archival tags. This rod and reel fishery is primarily catch and release; landings are restricted to one fish (27 to 73 inches) per vessel, with a no-sale provision. As part of the program to monitor the recreational North Carolina fishery, anglers are required to fill out a catch reporting card in exchange for a landing tag, which is necessary for offloading bluefin tuna.

General Category

Many anglers purchase a General category permit so they can sell any bluefin tuna larger than 73 inches which they might catch. The permit fee ($18 in 1997 and 1998) is small compared to the potential payoff if a commercial-sized bluefin tuna is landed. About 7,100 General category permits were issued in 1998, although only a few of the permitted vessels actually catch and sell fish in that category. Given that the recreational Angling category permit allows anglers to retain one giant “trophy” bluefin tuna per season, which they cannot sell, the preference for the General category permit clearly indicates an economic interest in commercial-sized fish, in addition to a recreational interest.

In 1998, only 11 percent of General and Charter/Headboat category permit holders landed a bluefin tuna measuring greater than 73 inches, and over 50 percent of those who did land and sell a bluefin tuna in the General or Charter/Headboat category landed only one or two fish. The total number of vessels landing bluefin tuna decreased from 1,027 vessels in 1997 to 965 vessels in 1998. For those vessels that landed a bluefin tuna in 1998, the average number of fish per vessel was 3.6 fish for the season. The General category figures are distorted somewhat, however, by the presence of recreational anglers holding General category permits prior to the 1998 change in the permit regulations. The average weight per fish increased from 408 lbs in 1997 to 442 lbs in 1998.

Harpoon Category

With only 21 vessels landing fish in 1998, the Harpoon category is the smallest of the directed fishery categories in value and volume of landings. The average number of bluefin tuna sold per Harpoon category vessel landing bluefin tuna was approximately 17 fish, and over 80 percent landed more than five fish in 1998. In contrast, the General category averaged less than four fish per “successful” vessel and only 20 percent of vessels landed more than five fish. Thus, “successful” vessels in the Harpoon category were “more successful” on average than General category vessels (Table 2.8). The average weight of each Harpoon category bluefin tuna has declined recently, from 414 lbs in 1996, to 403 lbs in 1997, to 376 lbs in 1998. There is antecdotal evidence which indicates that harpoon fishermen may be targeting smaller fish (300 to 400 lbs ww), due to the increased market demand in Japan and the higher prices received for these smaller giant bluefin.

Purse Seine Category

The purse seine fleet, as indicated above, consists of five vessels, each of which holds an equal amount of bluefin tuna quota (50 mt each in 1997 and 1998). Only four Purse Seine category vessels landed bluefin tuna in 1998, as one vessel transferred its quota to other vessels. The average number of bluefin tuna harvested by each of the four vessels in this category in 1998 was 366 fish. Each fish weighed an average of 373 lbs in 1998, down from the average of 433 lbs in 1997, and 456 lbs in 1996.

Incidental Catch Category (Longline and Trap)

In 1998, 240 bluefin tuna were landed incidentally to other fishing operations, primarily in longline fisheries targeting yellowfin tuna and swordfish. Bluefin tuna landed in the incidental category averaged 439 lbs in 1998, down from 448 lbs in 1997, and 539 lbs in 1996. Bluefin tuna were landed by 100 Incidental category permit holders in 1998. In 1998, only eight percent of those vessels landing under the Incidental category landed more than five fish. Target catch requirements on the incidental catch of bluefin tuna are intended to remove any incentive to target these bluefin tuna while minimizing dead discards. The annual U.S. allowance for dead discards is currently 68 mt. If there are dead discards in excess of this allowance, they must be counted against the following year’s quota. If there are fewer dead discards, then half of the underharvest may be added to the following year’s quota while the other half is conserved.

Angling Category

Nearly 8,000 vessels held Angling category permits in 1997, and over 10,000 vessels purchased or renewed Angling category permits for 1998. The ICCAT Rebuilding Plan for bluefin tuna specifies that bluefin tuna less than 115 cm may account for no more than eight percent by weight of the total bluefin tuna quota on a national basis. This recommendation provides additional flexibility to manage the eight percent limit over each four-consecutive-year quota balancing period. The recommendation also specifies that all countries must institute measures to deny economic gain to the fishermen from such fish; the United States has implemented this through a no-sale provision. Refer to Section 2.5.8 for a more detailed description of the handgear fishery for tuna. The total number of trips targeting large pelagics in 1997, by vessel type and by state, is shown in Table 2.9.

Rachel and Jim Husted with a tuna caught on the *Pickled Herring VI*. Photo credit: Joan Husted.

The number of recreational fishing trips targeting bluefin tuna in 1997 (Table 2.10) was calculated as follows: Trips for which respondents identified bluefin tuna as the target species were estimated through the 1997 Large Pelagic Survey. The number of recreational trips in North Carolina was estimated from a separate telephone survey conducted on the winter fishery. All trips with bluefin tuna as the target from Virginia to Rhode Island were assumed to be recreational trips. Since there is no differentiation between recreational and commercial trips in the Large Pelagic Survey, and the trips targeting bluefin tuna in Massachusetts, New Hampshire, and Maine are mostly commercial General category trips, the ratio of Angling category to General category permit holders in those states was used to approximate the percentage the total trips targeting bluefin tuna which were recreational. Because 6.7 percent of the total number of Angling and General category permits in Massachusetts, New Hampshire, and Maine are Angling category permits, 6.7 percent of the total number of bluefin tuna trips in those states were estimated to recreational trips. This procedure led to an estimate of 16,868 recreational trips targeting bluefin tuna. One potential bias of this estimate is that the Large Pelagic Survey only allows for one target species to be identified. For example, a fisherman cannot respond “yellowfin and bluefin”; it must be one or the other. Note that the methods used to calculate recreational catch of bluefin tuna use different assumptions to estimate landings of bluefin tuna.

The 1998 ICCAT Rebuilding Program for bluefin tuna reaffirmed the importance of providing the best available data on the broadest range of age classes possible, given minimum size restrictions. Scientific surveys of the bluefin tuna fleet, especially the rod and reel fleet in the General and Angling categories, provide a basis for both indexing the abundance of bluefin tuna and for estimating the harvest levels for some age classes in the stock. Trends in catch per unit effort (CPUE), or the amount of effort (in terms of gear, time, etc.) it takes to catch a certain quantity of fish, are used extensively in the stock assessments performed by SCRS, and can be important indicators of the health of the stock. It is important to keep the bluefin tuna fisheries that collect catch per unit effort information (i.e., the Angling and General categories) open over as long a time period and as large a geographic area as possible, because catch per unit effort can be influenced by many short-term and local factors (e.g., weather, brief high or low concentrations of fish). Collecting data over a long period of time and wide geographic area can help eliminate or reduce the effects of these short-term factors on catch per unit effort.

Table 2.7a Size classes for Atlantic bluefin tuna.

Size Class	Curved Fork Length	Pectoral Fin Curved Fork Length	Approximate Whole Weight
Young School	<27”	<20”	<14 lbs.
School	27 - <47”	20 - <35”	14 - <66 lbs.
Large School	47 - <59”	35 - <44”	66 - <135 lbs.
Small Medium	59 - <73”	44 - <54”	135 - <235 lbs.
Large Medium	73 - <81”	54 - <60”	235 - <310 lbs.
Giant	81” or >	60” or >	310 lbs. or >

Table 2.7 Summary of patterns of fishing activities directed at Atlantic bluefin tuna in the United States.

Gear	Area	Size of Fish	Season
Handline, Harpoon, and Rod and Reel	Cape Cod Bay and Gulf of Maine	Giant	June - September
		Medium	August - October
		School	Summer (unpredictable)
	Cape Hatteras to Cape Cod	School	June - October
		Medium	June - October
	Coastal North Carolina	Large Medium and Giant	December - March
	Gulf of Mexico	Giant	January - June
Purse Seine	Cape Hatteras to Cape Cod	Large Medium and Giant	August - October
	Cape Cod Bay	Large Medium and Giant	August - October

Table 2.8 Bluefin tuna fleet size and success rate, 1998*. (NMFS Atlantic tuna vessel permit database)

Quota Category	**Number of Permitted Vessels in 1998**	**Success Rate in 1998 (% of Vessels landing at least one BFT>73")**
General	9,143**	11%
Harpoon	59	36%
Purse Seine	5	80%
Incidental	319	31%
Angling	10,668	NA
TOTAL	**20,194**	**11% (commercial only)**

*Since those fishermen not selling a tuna may in any case consider themselves participants in the fishery, the percentage of vessels landing fish is referred to as the "success rate." Success rate should not, however, be interpreted as synonymous with economic success or performance, as costs are not being compared with returns.
**Includes Charter/Headboat permitted vessels

Table 2.9 Estimated number of rod and reel/handline fishing trips targeting large pelagics, 1997 (by vessel type and state)*. (1997 Large Pelagic Survey)

State	**Private**	**Charter**	**All Vessels**
North Carolina**	1,335	1,558	2,893
Virginia	8,190	2,470	10,660
Maryland to Delaware	2,112	5,761	26,873
New Jersey	39,813	8,557	48,370
New York	26,568	6,881	33,449
Connecticut to Rhode Island	9,675	3,449	13,124
Massachusetts	46,068	3,489	49,557
New Hampshire to Maine	23,177	1,596	24,773
TOTAL	**175,938**	**33,761**	**209,699**

* All figures are preliminary; LPS estimates the number of fishing trips only in northeast Atlantic states from Maine through Virginia.
** North Carolina estimates are from a separate telephone survey, for bluefin only.

Table 2.10 Estimated number of rod and reel/handline fishing trips targeting bluefin in 1997, by vessel type and geographic area *. (Large Pelagic Survey, 1997)

Area	Charter	Private	All
North Carolina **	1,558	1,335	2,893
Virginia to Rhode Island	2,345	8,509	10,854
Massachusetts to Maine	182	2,939	3,121
TOTAL	**4,085**	**12,783**	**16,868**

***** All figures are preliminary; the LPS estimates the number of fishing trips only in the northeast Atlantic states from Maine through Virginia.
** North Carolina estimates from separate telephone survey, and are for bluefin only.

Table 2.11 Domestic Atlantic bluefin tuna landings by year and category (metric tons), 1983 - 1998.

Category	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	
General	743	642	690	395	401	400	627	645	624	535.6	608.7	642	558	575	679	706
Harpoon	73	68	74	67	56	74	62	39	59	58.4	56.6	59	57	58	53	60
Purse Seine	374	398	377	360	367	383	385	384	236	300.0	295.3	301	249	245	250	248
Incidental	116	132	133	130	139	152	112	137	177	136.7	84.9	94	72	65	49	48
No. LL*	25	37	12	14	8	2	31	3	8	18.4	26.5	28	31	21	20	23
So. LL	91	92	120	115	130	149	80	133	168	117.2	56.7	64	40	43	27	24
Other	0	3	1	1	1	1	1	1	1	1.1	1.7	2	1	1	2	1
Angling	65	105	149	202	426	277	228	486	431	134.5	297	112	402	362	299 p	184 p

* - LL indicates longline gear.
p - Angling category figures for 1997 are preliminary
Sources: Landings data from Northeast Region mandatory dealer report program, except for Angling category landings which are survey-derived. Note that General category figures include school and medium fish sold by General category permit holders (up to July of 1992), and that Angling figures thus reflect school and medium fish caught and/or sold by non-permit holders.

Table 2.12 Domestic landings of bigeye tuna by area and gear, 1995 - 1997. (National Report of the United States: 1998)

Area	Gear	Total Landings of Bigeye Tuna (mt)		
		1995	1996	1997
NW Atlantic	Longline	659.8	383.9	476.3
	Rod and Reel**	19.8	147.5	292.5
	Troll	8.7	3.5	3.9
	Gillnet	3.6	2.6	*
	Handline	*	15.0	2.7
	Pairtrawl	193.6	0.0	0.0
	Trawl	0.9	0.4	1.0
	Unclassified	0.0	0.0	0.5
Gulf of Mexico	Longline	68.9	29.3	33.9
	Rod and Reel**	0.0	0.0	0.0
	Handline	0.0	0.0	*
Caribbean	Longline	122.5	137.8	50.0
NC Area 94a***	Longline	130.0	129.0	91.8
SW Atlantic	Longline	0.0	32.7	142.8

* ≤ 0.05 MT
** Rod and reel catches represent estimates of landings and dead discards based on statistical surveys of the U.S. recreational harvesting sector
*** Numbered areas refer to an ICCAT system for reporting catches. Area 94a is primarily the Grand Banks but may also include other offshore areas which are outside the U.S. EEZ. Virtually all the U.S. effort in area 94a is longline effort. The catch locations of landings data is often not precise enough to differentiate between catches from areas 92 and 94a. For a diagram of these ICCAT catch areas, refer to SCRS, 1990.

Table 2.13 Domestic landings of north Atlantic albacore tuna by area and gear, 1995 - 1997. (National Report of the United States: 1998)

Area	Gear	Total Landings of Albacore Tuna (mt)		
		1995	1996	1997
NW Atlantic	Longline	238.8	65.4	140.0
	Gillnet	3.0	30.5	42.8
	Handline	*	2.1	4.8
	Trawl	0.0	1.4	2.6
	Troll	1.1	2.6	1.6
	Rod and Reel **	22.8	246.6	31.9
	Pair Trawl	144.9	0.0	0.0
	Other	0.0	3.5	1.5
Gulf of Mexico	Longline	9.5	4.7	16.9
	Rod and Reel **	***	61.7	65.2
Caribbean	Longline	119.1	40.5	16.1
NC Area 94a	Longline	6.1	11.6	11.4
SW Atlantic	Longline	-	1.1	4.7

* $\leq$ 0.05 MT
** Rod and reel catches represent estimates of landings and dead discards based on statistical surveys of the U.S. recreational harvesting sector
*** Numbered areas refer to an ICCAT system for reporting catches. Area 94a is primarily the Grand Banks but may also include other offshore areas which are outside the U.S. EEZ. Virtually all the U.S. effort in area 94a is longline effort. The catch locations of landings data is often not precise enough to differentiate between catches from areas 92 and 94a. For a diagram of these ICCAT catch areas, refer to SCRS, 1990.

Table 2.14 Domestic landings of Atlantic yellowfin tuna by area and gear, 1995 - 1997. (National Report of the United States: 1998)

Area	Gear	Total Landings of Yellowfin Tuna (mt)		
		1995	1996	1997
NW Atlantic	Longline	1,393.3	750.6	838.9
	Rod and Reel	4,024.7	4,021.2	3,519.8
	Troll	289.8	292.9	218
	Purse Seine	0.0	6.8	0.0
	Gillnet	3.6	9.2	1.3
	Pairtrawl	47.0	0.0	0.0
	Trawl	1.2	1.8	1.9
	Harpoon	0.0	0.0	0.0
	Handline	69.3	31.5	34.3
Gulf of Mexico	Longline	1,846.9	2,110.8	2,571.3
	Rod and Reel	27.8	11.2	0.0
	Handline	22.5	49.7	55.6
Caribbean	Longline	388.3	414.9	135.4
	Troll	-	0.0	19.6
	Handline	-	0.0	0.7
	Gillnet	-	-	*
	Trap		0.0	0.1
NC Area 94a	Longline	16.9	6.7	6.1
SW Atlantic	Longline	-	36.2	221.9

* $\leq$ 0.05 MT
** Rod and reel catches represent estimates of landings and dead discards based on statistical surveys of the U.S. recreational harvesting sector
*** Numbered areas refer to an ICCAT system for reporting catches. Area 94a is primarily the Grand Banks but may also include other offshore areas which are outside the U.S. EEZ. Virtually all the U.S. effort in area 94a is longline effort. The catch locations of landings data is often not precise enough to differentiate between catches from areas 92 and 94a. For a diagram of these ICCAT catch areas, refer to SCRS, 1990.
**** These data are under review and may be revised a later date.

Table 2.15 Domestic landings of west Atlantic skipjack tuna by area and gear, 1995 - 1997. (National Report of the United States: 1998)

Area	Gear	Total Landings of Skipjack tuna (mt)		
		1995	**1996**	**1997**
NW Atlantic	Longline	0.0	0.3	1.0
	Rod and Reel	20.7	46.7	29.9
	Troll	0.0	0.8	0.6
	Purse Seine	0.0	0.9	0.0
	Gillnet	0.0	0.0	8.9
	Trawl	0.0	0.0	0.0
	Handline	0.0	**	0.1
	Unclassified	60.2	0.0	0.0
Gulf of Mexico	Longline	0.0	0.2	1.3
	Rod and Reel	0.0	34.8	21.6
Caribbean	Longline	-	0.0	1.2
	Gillnet	-	0.0	0.2
	Trap	-	0.0	**
	Troll	-	0.0	7.3
TOTAL	**All Gears**	**80.9**	**83.7**	**72.2**

* ≤ 0.05 MT
** Rod and reel catches represent estimates of landings and dead discards based on statistical surveys of the U.S. recreational harvesting sector
*** Numbered areas refer to an ICCAT system for reporting catches. Area 94a is primarily the Grand Banks but may also include other offshore areas which are outside the U.S. EEZ. Virtually all the U.S. effort in area 94a is longline effort. For a diagram of these ICCAT catch areas, refer to SCRS, 1990.

2.2.4 Social and Economic Aspects of the Domestic Atlantic Tuna Fishery

2.2.4.1 Bluefin Tuna

Prices and Markets in the Commercial Fishery

The ex-vessel price of bluefin tuna in the United States has increased substantially over the past two and a half decades, from roughly $0.20 per pound to approximately $8.00 per pound whole weight (ww). This increase is largely attributed to demand for fresh bluefin tuna in Japan, the principal consumer of bluefin tuna landed by U.S. fishermen. Prices in the late 1990s have declined somewhat as a result of the Asian economic crisis. The prices paid to U.S. fishermen and exporters depend on a range of factors including the preferences of Japanese consumers, supplies of competitive product in Japan (e.g., Atlantic bluefin tuna from other nations, Pacific bluefin tuna, bigeye tuna), packing and transportation costs, and the yen/$U.S. exchange rate. Carroll (1998) econometrically examined factors that influence ex-vessel prices of U.S. Atlantic bluefin tuna and found that fish quality factors (fat content, shape, color) and other factors such as the yen/$U.S. exchange rate and quantity of fish on the Japanese market significantly affect U.S. ex-vessel prices. Variability in supply and prices demonstrate the volatility of the Japanese market and the difficulty in predicting even general price trends on a monthly basis. Although a fatter fish may fetch a higher price whatever the market conditions, prices for lower quality bluefin tuna may be higher if total supplies to the Japanese market are relatively low.

A 900-lb giant bluefin tuna caught by rod and reel by the crew of the *Tuna Hunter* off Rockport, MA on September 8, 1998. Pictured are Capt. Gary Cannell (r), buyer William Raymond (l) and angler, Jim Chambers. Photo credit: Jim Chambers.

As mentioned above, in addition to market conditions, fish quality and condition are also important factors. Bluefin tuna are evaluated by expert graders on the basis of four criteria: fat, freshness, color and shape of the fish, with a letter grade of A, B, or C for each of the criteria. Since 1994, NMFS has asked dealers to supply, on a voluntary basis, quality ratings on the individual fish they purchased. Because Atlantic bluefin tuna gain weight during the late summer months, the time period of catches roughly reflects fat content, and thus can serve as a proxy for quality in predicting prices. Size can also be an important determinant of price per pound. According to industry sources, prices offered for individual bluefin tuna peak in the range of 500 to 700 lbs ww due to the costs and the risk of investing upwards of $10,000 or more for individual fish, as well as the problems in physically handling larger fish. Industry sources also indicate that with the recent Asian economic crisis, the Japanese market is more receptive to smaller bluefin tuna of approximately 250 to 400 lbs ww, since they require less of an investment by the purchaser in Japan and thus have a broader market.

Table 2.16 shows average prices by commercial quota category for the U.S. bluefin tuna fishery for 1994 to 1998. Ex-vessel prices have been declining since 1995. For example, prices in the General category averaged $14.45 per pound dressed weight (dw) in 1995, $10.89 per pound in 1996, $8.91 per pound in 1997, and $6.26 per pound in 1998. This decline in prices may be due to the appreciation of the dollar relative to the yen over the last three years, as well as market supply conditions in Japan. In addition, a weak economy in Japan led to a decline in the demand for luxury goods such as top-quality sushi. Harpoon category prices, however, did not drop in 1997 from 1996, and did not fall as low as General category prices in 1998. This may be due to favorable market conditions in late June and very early July when much of the Harpoon category quota is caught.

Table 2.16 Ex-vessel average nominal prices (per pound, dw) for Atlantic bluefin tuna by commercial fishing category, 1994 - 1998. (NERO Bluefin Dealer Report Database).

Category	1994	1995	1996	1997	1998*
General	10.86	14.45	10.89	8.91	6.26
Harpoon	14.88	16.41	9.62	10.09	7.13
Incidental	8.48	9.87	5.99	6.67	6.04
Purse Seine	10.23	11.07	11.05	10.34	7.23

*1998 data are preliminary

Ex-vessel revenues from recorded sales of bluefin tuna in all commercial categories for 1994 to 1998 are presented in Table 2.17. General category gross revenues remained constant from 1996 to 1997, but decreased in 1998. Landings in 1998 were similar to 1997, but due to the reduction in average prices, ex-vessel revenues dropped. In the Purse Seine category, the 17 percent quota decrease from 1994 to 1995 resulted in only a ten percent decline in gross revenues. Adjustments to purse seine operations may have partially offset the economic effects of the quota decrease. For example, there is evidence that over the past four seasons, purse seine operators attempted to slow the volume of their landings and to market more fresh product in order to increase ex-vessel prices. In addition, cost-saving mechanisms could result in an even smaller decline in actual producer surplus, particularly since purse seine quotas are now freely tradeable within the Purse Seine category. Transferable output quotas should result in increased economic efficiency in fishing operations, and thus higher producer surplus, all else being equal.

Table 2.17 Ex-vessel gross revenues in the U.S. Atlantic bluefin tuna fishery by commercial fishing category, 1994 - 1998. (NERO Bluefin Dealer Report Database)

Category	1994	1995	1996	1997	1998*
General	$12,279,518	$13,933,311	$10,781,388	$10,567,634	$7,411,803
Harpoon	$1,579,860	$1,568,566	$919,717	$900,108	$715,752
Incidental	$1,350,573	$1,210,929	$671,528	$503,302	$474,545
Purse Seine	$5,230,451	$4,670,978	$4,445,852	$4,581,837	$3,158,582
TOTAL*	**$20,440,402**	**$21,383,784**	**$16,818,485**	**$16,562,066**	**$11,760,682**

May include revenues from bluefin counted towards the Reserve quota
*1998 data are preliminary

The vast majority of commercial bluefin tuna are landed and sold in New England. Table 2.18 shows the landings and value for bluefin tuna for each state in which dealers reported purchases in 1997 and 1998. Massachusetts accounts for the vast majority of landings and value. Commercial landings south of New York and in the Gulf of Mexico states are almost exclusively those from the Incidental category quota on longline gear, with the exception of a few General category fish landed between New Jersey and North Carolina.

Table 2.18 Bluefin tuna landings and value by state of landing, 1997 - 1998. (NERO Bluefin Dealer Report Database)

	1997		**1998***	
	Landings (pounds, ww)	**Value**	**Landings (pounds, ww)**	**Value**
Massachusetts	1,734,97	$12,986,205	1,658,887	$8,602,309
Maine	284,218	$2,034,882	396,507	$1,817,880
New Hampshire	143,362	$1,012,588	170,523	$846,824
Louisiana	43,326	$206,952	33,209	$157,330
New York	13,798	$79,392	25,765	$91,256
Florida	11,027	$28,686	16,170	$48,529
New Jersey	19,028	$97,868	18,709	$110,437
North Carolina	14,007	$77,557	26,752	$28,550
Texas	7,142	$17,700	2,678	$8,588
Maryland	1,655	$5,874	5,911	$31,107
Rhode Island	973	$5,671	2,065	$12,836
Virginia	0	0	580	$3,045
South Carolina	531	$4,059	638	$2,040
Alabama	0	0	538	$1,075
Puerto Rico	745	$4,632	668	$1,297
Virgin Islands	0	0	588	$1,645
TOTAL	**2,274,783**	**$16,562,066**	**2,360,188**	**$11,764,748**

*1998 data are preliminary

U.S. fishermen can sell their catch "dockside" for a negotiated price or have the tuna dealer sell their fish on consignment. When a dealer buys a bluefin tuna at a negotiated dockside price, the dealer is bearing the market risk, but when a fish is sold on consignment, the market risk is borne by the fisherman. Table 2.19 shows the number of bluefin tuna sold on consignment and dockside for 1996 through 1998. For the Harpoon, General, and Incidental categories, most fish are sold on consignment, but the number of fish being sold on consignment has dropped over the last few years as prices have fallen. This may be because fishermen are less willing to bear the market risk in a market with a weak Japanese Yen and an ongoing Asian economic crisis. Purse Seine category fish are generally sold for a dockside price, and purse seine vessels have traditionally negotiated set prices with dealers before their season begins. The relative number of Purse Seine category fish sold on consignment more than quadrupled from 1996 to 1998, however. This may be because dealers are unwilling to take on all the risk of selling the fish in a weak market. While a higher percentage of bluefin tuna are still sold dockside in the Purse Seine category and more fish are sold on consignment in the other categories, the difference is being reduced as neither dealers nor fishermen are willing to bear all the market risk. Table 2.20 shows that average prices for bluefin tuna sold on consignment are generally higher, but vary more than dockside prices (indicated by higher standard deviations).

Table 2.19 Numbers of bluefin tuna sold dockside vs. consignment, 1996 - 1998. (NERO Bluefin Dealer Report Database)

	Non-Purse Seine		**Purse Seine**	
	Dockside	**Consignment**	**Dockside**	**Consignment**
1996	857	2,968	1,032	106
1997	962	3,199	1,000	271
1998*	1,499	2,347	1,016	448

*1998 data are preliminary

Table 2.20 Average ex-vessel prices for bluefin tuna sold dockside and on consignment, 1996 - 1998. (NERO Bluefin Dealer Report Database)

	Non-Purse Seine				**Purse Seine**			
	Dockside		**Consignment**		**Dockside**		**Consignment**	
	Average $/lb.	**Std. Dev.**	**Average $/lb.**	**Std. Dev.**	**Average $/lb.**	**Std. Dev.**	**Average $/lb.**	**Std. Dev.**
1996	7.24	4.26	8.68	4.57	8.54	0.54	9.41	3.03
1997	6.36	3.02	7.35	4.00	8.53	0.08	7.60	0.72
1998*	4.37	2.59	5.47	3.30	5.69	0.54	6.00	1.32

*1998 data are preliminary

An annual Atlantic tuna dealer permit is required for fish dealers who purchase, import, or export bluefin tuna. In 1998, there were approximately 500 permitted Atlantic tuna dealers. However, only 68 of these dealers actually purchased a bluefin tuna in 1998. Table 2.21 shows the distribution of bluefin tuna purchases by dealers for

1995 through 1998. While there are numerous bluefin tuna dealers, there appear to be few who are handling large volumes of bluefin.

Table 2.21 Distribution of bluefin tuna ex-vessel purchases, 1995 - 1998. (NERO Bluefin Dealer Report Database)

Number of BFT Purchased	Number of Dealers			
	1995	1996	1997	1998*
≤10	40	39	34	31
11-20	7	7	8	10
21-30	5	6	3	2
31-50	6	4	8	4
51-70	2	3	2	6
71-100	6	4	3	3
101-150	6	1	3	3
151-200	2	3	0	1
201-300	1	1	0	1
301-600	3	4	6	5
> 600	2	2	3	2
TOTAL	**77**	**75**	**70**	**68**

*1998 data are preliminary

Costs and Expenses in the Commercial Fishery

Collection of cost data in the bluefin tuna fishery is difficult because of the seasonal nature of the fishery and the varying motivations of the participants (profit, fun, or a combination of both). The variable costs of fishing for bluefin tuna are discussed separately for each permit category. Fixed costs are not included in these calculations. The level of capital investment in vessels, gear, and other equipment is considerable in both the recreational and commercial fisheries for bluefin tuna. It is assumed that commercial vessels will continue to fish as long as variable costs are covered, at least in the short run, since fixed costs are incurred whether or not the vessel engages in fishing. For both commercial and recreational vessels, it is assumed that a number of species may be targeted, and the relevant decision is which species the vessel operator chooses to target.

Some information about expenses in the General category is available from various surveys. A non-random sample of 15 vessel owners in the General Category Tuna Association (GCTA) responded to a questionnaire on fishing costs and success. Average variable cost per fishing trip for 1997 was estimated at $516 for those vessels providing information, with an average of 3.8 trips taken per bluefin tuna landed. This estimate is substantially greater than estimates from a previous study of costs in the General category which estimated average costs per trip for 1994 at $388 (Watson, 1996). Previous studies of the Virginia and New Jersey recreational fisheries estimated costs at an average of $375 per day (Lucy *et al*., 1990; Ofiara and Brown, 1987), similar to estimates in the Final Environmental Impact Statement for Bluefin Tuna (NMFS, 1995). This difference may be explained by the fact that the GCTA survey respondents are more active in the fishery than the average General category permit holder. For the purpose of the analyses in this FMP, information from the GCTA survey regarding the average variable cost and average number of trips per fish will be used. Average variable costs from the GCTA survey multiplied by the number of trips necessary to land a fish (for those able to land a fish) result in an average variable cost per fish landed of approximately $1,960.

Due to its seasonal nature and limited duration, the General category bluefin tuna fishery is rarely the sole source of a fishermen's income. Many commercial fishermen in the General category fish commercially for other species (e.g., groundfish, lobster) during the rest of the year, and use the bluefin tuna fishery as an additional source of income. Although the bluefin tuna season is short, it may provide a significant percentage of a fisherman's income due to the high price per pound relative to other species.

According to the 1996 Watson study, average variable costs per trip for the Harpoon category were approximately $488 per trip in 1994, and the average Harpoon category vessel surveyed made 23 trips and landed ten bluefin tuna that year. Multiplying the average variable costs and number of trips necessary to land a bluefin tuna results in an average variable cost per fish of approximately $1,150 for the Harpoon category.

Through the cooperation of Purse Seine vessel owners, data were obtained for 1994 seasonal fishing costs for the Purse Seine category. NMFS was unable to obtain updated information for this FMP. Variable costs, including crew wages and payroll taxes, fish spotting services, fuel, supplies, food, travel, lodging, and unloading, were estimated to be slightly over $ 1 million per vessel. Purse seiners indicate that their variable fishing expenses when targeting bluefin tuna are approximately $1,750 per day, plus crew share costs. Given an annual average of 30 to 40 days for each vessel to fill its quota, and a share of 55 to 60 percent of the gross revenue to the crew members, an estimate of $10,580 of variable harvesting costs per metric ton was calculated for bluefin tuna landed in the Purse Seine category. Fixed costs of insurance, professional fees, and office fees averaged just over $100,000 per vessel. Depreciation, opportunity costs of capital, dry docking, and the costs of activities in other fisheries were not estimated.

If the "incidental" catch of a bluefin tuna is truly incidental (that is, if fishermen would have made the same trip and fished in the same manner) then the cost of catching a bluefin tuna incidentally is essentially zero. Only handling costs can be directly attributed to the catch of bluefin tuna, and these are assumed to be minimal. Rules that require minimum landings of a target species for every bluefin tuna landed are designed to minimize the incentive for Incidental category participants to target bluefin tuna. Although the possibility of catching a valuable bluefin tuna could still have some effect on fishing practices, there are insufficient data to determine the nature or extent of this effect. Therefore, in this analysis the basic assumption is that bluefin tuna catches are truly incidental and that the associated costs of incidental catch are zero. This assumption simplifies the calculation of producer surplus for the Incidental category, since the profits are equal to gross revenues from the sales of bluefin tuna.

Exports and Imports

Most Atlantic bluefin tuna landed by the U.S. commercial fishery are exported fresh to Japan for auction in a wholesale market, usually the large Tsukiji Central Wholesale Market in Tokyo. The percentage of landings which are exported is lowest at the start of the season when fat content is low, increasing to nearly 100 percent in late summer and early fall. According to the East Coast Tuna Association, virtually all U.S. exports of Atlantic bluefin tuna are conducted by U.S. companies or agents; that is, Japanese ownership of tuna landed by U.S. fishermen generally begins after first sale in Japan.

All bluefin tuna imported to, or exported from, the United States must be accompanied by a Bluefin Statistical Document (BSD) in order to meet the requirements of ICCAT's Bluefin Statistical Document Program, which began in 1995. The original (for imports) or a copy (for exports) of the completed BSD must be sent to the NMFS Northeast Regional Office within 24 hours of the bluefin tuna shipment entering or leaving the United States. In 1998, the United States exported 658.6 mt dw of Atlantic bluefin tuna from a total of 849.1 mt dw landed. An additional 701 mt dw of Pacific bluefin tuna were reported as exported in 1998 through the BSD program, much of it in bulk shipments of frozen, gilled and gutted fish. Bluefin tuna exports from the United States for 1996 through 1998 are shown in Table 2.22. Many other nations, including Canada, Spain, Tunisia, and Australia also export appreciable amounts of fresh bluefin tuna to Japan (southern bluefin tuna in the case of Australia).

Table 2.22 United States exports of bluefin tuna (Atlantic and Pacific), as reported through the Bluefin Tuna Statistical Document Program, 1996 - 1998. (U.S. BSD Program, NMFS NERO)

	Landings of Atlantic BFT (mt, dw)	**Exports of Atlantic BFT (mt, dw)**	**Exports of Pacific BFT (mt, dw)**	**Total U.S. Exports of BFT (mt, dw)**
1996	749.8	661.7	60.7	722.4
1997	826.8	698.7	917.3	1,616.0
1998*	849.1	658.6	701.0	1,359.6

*1998 data are preliminary

Importers of bluefin tuna are also required to obtain an annual tuna dealer permit and to report through the BSD program. Since 1997, NMFS has received U.S. Customs data (derived from Entry Form 7501) on imports of fresh and frozen bluefin tuna and swordfish on a monthly basis. These data allow NMFS to track shipments of bluefin tuna and enforce dealer reporting requirements. United States imports and re-exports of bluefin tuna for 1996 through 1998, as reported through both U.S. Customs and the BSD program, are shown in Table 2.23.

The U.S. Customs data indicate that 109.5 mt of bluefin tuna were imported into the United States from July through December of 1997, much more than the 5.7 mt reported as imported through the BSD program (imports plus re-exports). However, the U.S. Customs and preliminary BSD data match up more closely for 1998, with 225.6 mt of imports reported through U.S. Customs and 101.7 mt reported through the BSD program (99.8 mt of imports and 1.9 mt of re-exports). The difference in import numbers between the U.S. Customs and BSD data may be explained by a lack of knowledge and compliance with the BSD program by importers, especially those on the Pacific coast.

Data transferral between NMFS and U.S. Customs helps NMFS to verify the bluefin tuna import data it currently receives from dealers and identify those importers who are not in compliance with the BSD program. This is especially important as industry sources report that imports of bluefin tuna into the United States are on the rise as the value of the dollar remains high compared to other currencies and the Asian economic crisis continues.

Table 2.23 Imports of bluefin tuna into the United States, as reported through the BSD program and U.S. Customs, 1996 - 1998 (U.S. BSD Program, NMFS NERO; and U.S. Customs)

	U.S. BSD Program		**U.S. Customs Data (mt, dw)**
	Imports (mt, dw)	**Re-exports (mt, dw)**	
1996	1.9	1.3	N/A
1997	5.3	0.4	109.5
1998*	99.8	1.9	225.6

*1998 data are preliminary

Processing and Trade

To maximize fish quality, much of the processing of export-quality Atlantic bluefin tuna in the commercial categories takes place on board the vessel. Fishermen maintain freshness by gutting and bleeding the fish and protecting it from heat and sunlight, preferably by immersing it in ice or an ice brine. Following these procedures can be more difficult for smaller vessels which may have to tow a fish to port, and for purse seiners due to their large harvests in one trip. Over the last two years, however, the purse seine vessels have done more at-sea processing (removing gill plates, gutting, and bleeding), than in the past in order to ensure quality and to receive higher prices.

Once landed, most Atlantic bluefin tuna are immediately graded and prepared for export to Japan's fresh fish market. Export-quality fish are either refrigerated or placed into an ice water bath until ready for export. Fish are then placed individually in insulated crates, commonly known as "coffins," filled with ice for transport to an airport and flight to Japan. Dealers earn a commission ranging from four percent to nine percent for consignment fish, and fishermen also pay expenses for shipping, handling, tariffs, and customs (Weber, 1990). Industry sources report that for fish that are shipped on consignment, dealers charge approximately $3.00 to $3.50 per pound for shipping, handling, wharf fees, etc.

Charter/Headboat Fishing

In 1997, the Large Pelagic Survey estimated 6,612 charterboat trips targeting bluefin tuna from Maine to North Carolina. Of these trips, 2,527 targeted commercial-sized bluefin tuna which, if caught, were sold under the General category quota. Assuming that charterboats charge about $800 per day, the gross revenues from bluefin tuna fishing would be about $5.3 million. These direct revenues represent greater than 20 percent of the total gross revenues to the other commercial permit categories, and are likely an underestimate of revenues accruing to the charterboat sector because some of the large medium or giant bluefin tuna landed may be sold by the captain or mate. Additionally, tips that are typically given to the mate (about $100 per trip), are not included. The producer surplus component of the bluefin tuna fishery would thus be these gross revenues minus costs incurred in providing the charterboat services. Variable costs incurred in providing charterboat services are estimated at $392 per trip, as described below. This estimate results in a producer surplus for charterboat operations targeting bluefin tuna of $800 minus $392, or $408 per trip, not including tips. Assuming 6,612 charterboat trips targeted bluefin tuna, this results in a total producer surplus for the charterboat bluefin tuna fishery of approximately $2.7 million in 1997.

Studies in Virginia (Lucy *et al*., 1990) and New Jersey (Ofiara and Brown, 1987) reported costs associated with recreational fishing (including charterboats) for “big game” fish. Average expenses were $375 per trip (in 1992 dollars), as reported by the vessel owner. In many cases, trip expenses were likely shared in some part among several passengers on board. In the New Jersey study, there were an average of 4.7 people on board; in the Virginia case there were 4.1 anglers per trip. The Ditton study on the bluefin tuna fishery in North Carolina estimates average expenses of $1,184 per trip (in 1997 dollars), with an average of 4.3 anglers on board.

Since these studies combined data for private and charterboats, they do not draw independent conclusions about the charter and recreational fisheries. In general, charterboats are larger and more expensive to operate than private vessels. At a minimum, charterboat variable costs per trip will include private vessel costs, plus wages for the mate of about $80 per trip, for a total of $392 (Virginia and New Jersey averaged). Expenses for anglers on a charterboat (assuming the charterboat fee of $800 per trip is split between six anglers) would include the charter fee, meals and lodging expenses (estimated at about $100 per person), plus tips (10 to 15 percent of charter cost), for a total of $260 per person. There were approximately 4,085 charterboat trips in 1997 that targeted recreational-sized bluefin tuna. An additional 2,527 charterboat trips targeted commercial-sized bluefin tuna which, if caught, were sold by the vessel owner or operator under the General category quota.

Recreational Fishing

Revenue estimated through angler consumer surplus (ACS) in the private bluefin tuna fishery is $1,132 per fishing trip (NMFS, 1995). Using this estimate of angler consumer surplus per trip and an estimated 16,868 recreational bluefin trips per year (based on 1997 Large Pelagic Survey data), total angler consumer surplus for the recreational bluefin tuna fishery was $19,094,576 in 1997. In a recent study of the winter recreational bluefin tuna fishery, angler expenditures in North Carolina were estimated to be $3.8 million in 1997 (Ditton *et al*., 1998). Angler "willingness to pay" above trip costs was found to be $344 to $388 per person; multiplying this estimate by the average number of anglers per trip (5.3) results in an estimated angler consumer surplus of $1,479 to $1,668. The North Carolina bluefin tuna fishery is unique, as anglers travel great distances to participate in a primarily catch and release fishery for large bluefin tuna. However, for the purposes of the analyses in this FMP, NMFS' value of $1,132 will be used to represent angler consumer surplus per trip for the recreational bluefin tuna fishery, coastwide.

The latest supplemental social and economic impacts survey of the Large Pelagic Survey, conducted in 1993, indicated that average variable costs for a private vessel targeting bluefin tuna were $315 per trip. Travel costs were estimated based on mileage between the home and the point where the vessel is moored, and averaged $27 per angler. According to the 1997 Large Pelagic Survey, an estimated 12,783 private vessel trips targeted bluefin tuna recreationally. Based on this number of trips, total expenditures are estimated to be $4 million. Also, see the above section for studies that estimated the costs of both recreational fishing for private anglers and charterboats.

2.2.4.2 BAYS Tunas

Commercial Fishing

BAYS tunas support substantial commercial fisheries along the coasts of the Atlantic Ocean and Gulf of Mexico. Albacore and skipjack tunas are sold primarily to the canning market, while bigeye and yellowfin tunas are sold primarily on the fresh market for domestic use and for export. As described in Section 2.3, there is significant economic interdependence between the swordfish and tuna longline fisheries, and fishery management regulations adopted for one directed fishery have indirect impacts on the other directed fishery (Taylor *et al*., 1995). As quotas have been reduced in the swordfish fishery, directed swordfish effort has declined and effort has increased in the tuna fishery. This trend is reflected in landings in the longline fishery, where landings of yellowfin and bigeye tunas have become an increasingly important component of total landings and gross revenues.

The longline fishery off the mid-Atlantic and southern New England is a multi-species fishery. Some vessels participate in the directed bigeye and yellowfin tuna fishery during the summer and fall months and then switch to bottom longline fisheries and/or shark fishing during the winter when the shark season is open. Fishing trips in this fishery sector average 12 sets over 18 days. During the season, vessels primarily offload in the major ports of Fairhaven, MA; Montauk, NY; Barnegat Light, NJ; Ocean City, MD; and Wanchese, NC. Average ex-vessel prices are shown in Table 2.24. As mentioned earlier, estimates of recreational and commercial harvests of BAYS tunas continue to be reviewed and may be revised in the future.

Table 2.24 Average ex-vessel prices for BAYS tunas (dressed weight), 1997 - 1998. (NMFS Southeast Dealer Database)

	1997 Average Price/pound (dw)	1998 Average Price/pound (dw)
Yellowfin tuna	$2.44	$2.21
Bigeye tuna	$3.53	$3.22
Other tuna (includes skipjack, albacore, blackfin, little tunny, bonito)	$0.75	$0.67

Recreational and Charter/Headboat Fishing

BAYS tunas support extensive recreational fisheries, and they are an important source of direct income to charter/headboat vessels. The private recreational and charter fisheries for BAYS tuna have become more important as stricter catch limits and shorter fishing seasons have been implemented for bluefin tuna, and BAYS tuna have become a more important component of these vessels' offshore catch. They are also an indirect source of income to U.S. firms that supply recreational fishery participants with associated goods and services. Non-market values are difficult to estimate, and involve either direct questioning (contingent valuation) or indirect survey techniques such as the travel cost method, as a basis for estimating demand (and thus consumer surplus) for recreational fishing. (Refer to Chapter 7 for a more complete description of the estimation process.) The economic importance of the recreational Atlantic tuna fisheries, including non-market benefits, should be considered when examining the gross revenue, despite the difficulty in attaching a dollar value to recreational fisheries.

A typical private recreational boat out of Ocean City, MD.
Photo credit: Sallie J. Stevenson.

Angler consumer surplus estimates for bluefin and yellowfin tunas, although now somewhat dated relative to changes in the regulations, indicate that net economic benefits from the recreational fishery are significant. Estimates of anglers' "willingness to pay" for recreational offshore fishing trips can exceed $1,000 per trip above and beyond the actual costs of their trip.

2.3 Atlantic Swordfish

2.3.1 Life History and Status of the Stocks

Swordfish are members of the family *Xiphiidae*, in the suborder *Scombroidei*. They are one of the largest and fastest predators in the Atlantic Ocean, reaching a maximum size of 530 kg (1165 lbs). Like other highly migratory species, they have developed a number of specialized anatomical, physiological, and behavioral adaptations (Helfman *et al*., 1997). Swordfish are distinguished by a long bill that grows forward from the upper jaw. This bill differs from that of marlins (family *Istiophoridae*) in that it is flattened rather than round in cross section, and smooth rather than rough. Swordfish capture prey by slashing this bill back and forth in schools of smaller fish or squid, stunning or injuring their prey in the process. They may also use the bill to spear prey, or as a defense during territorial encounters. Broken swordfish bills have been found embedded in vessel hulls and other objects (Helfman *et al*., 1997; Moyle and Cech, Jr., 1996).

Swordfish move thousands of kilometers annually throughout the world's tropical, sub-tropical, and temperate oceans and adjacent seas. They are pelagic fish, usually found in surface waters but occasionally diving as deep as 650 meters. As adults and juveniles, swordfish feed at the highest levels of the trophic food chain, implying that their prey species occur at low densities. The foraging behavior of swordfish reflects the broad distribution and scarcity of appropriate prey; they often aggregate in places where they are likely to encounter high densities of prey, including areas near current boundaries, convergence zones, and upwellings (Helfman *et al*., 1997).

Like most large pelagic species, swordfish have adapted body contours that enable them to swim at high speeds. Their streamlined bodies are round or slightly compressed in cross section (fusiform), and their stiff, deeply forked tails minimize drag. This streamlined physical form is enhanced by depressions or grooves on the body surface into which the fins can fit during swimming. The extremely small second dorsal and anal fins of the swordfish may function like the finlets of tuna, reducing turbulence and enhancing swimming performance. Their method of respiration, known as ram gill ventilation, requires continuous swimming with the mouth open to keep water flowing across the gill surfaces, thereby maintaining an oxygen supply. This respiratory process is believed to conserve energy compared to the more common mechanism whereby water is actively pumped across the gills (Helfman *et al*., 1997). In addition to the benefits of speed and efficiency, their search for prey is aided by coloring that provides camouflage in pelagic waters. This shading is darker along the dorsal side and lighter underneath, enhanced by silvery tones.

Swordfish exhibit other physiological characteristics that enable them to extend their hunting range. For example, swordfish can maintain elevated body temperatures, conserving the heat generated by active swimming muscles. Swordfish have developed a heat exchange system that allows them to swim into colder, deep water in pursuit of prey. Because warm muscles contract faster than cool ones, heat conservation is believed to enable these predatory fishes to channel more energy into swimming speed. The internal temperatures of these fishes remains fairly stable even as they move from surface waters to deep waters.

Swordfish have also adapted specialized eye muscles for deep water hunting. Because their eye muscles do not have the ability to contract, they produce heat when stimulated by the nervous system, locally warming both the brain and eye tissues (Helfman *et al*., 1997). With this modification, swordfish are able to hunt in the frigid temperatures of deep-water ocean environments without experiencing a decrease in brain and visual function that might be expected under such harsh conditions.

Juvenile swordfish are characterized as having exceptionally fast growth during the first year (Prince *et al.*, 1988). Adult swordfish exhibit dimorphic growth; females show faster growth rates and attain larger sizes than males (Ehrhardt *et al.*, 1996). Fifty percent of all males are mature between 112 cm (16 kg ww) and 129 cm (25 kg ww) lower jaw fork length (LJFL), an age of approximately 1.4 years, while 50 percent of all females are mature between 179 to 182 cm LJFL (72 to 74 kg ww), an age of approximately 5.5 years (Taylor and Murphy, 1992). All males are mature by 145 to 160 cm LJFL (37 to 50 kg ww), approximately age five, and all females are mature by 195 to 220 cm LJFL (93 to 136 kg ww), approximately age nine. In general, swordfish reach 140 cm LJFL (33 kg ww) by age three and are considered mature by age five (ICCAT, 1997). Individual females may spawn numerous times throughout the year.

Swordfish stocks consist of several age classes, a condition that may serve as a buffer against adverse environmental conditions and confer some degree of stability on the stocks. Since the distribution patterns of different size swordfish appear to be influenced by thermal conditions, abundance indices used in analytical assessments should account for these environmental factors (SCRS, 1996a). Swordfish are also at a high trophic level which may make the species less vulnerable to short-term fluctuations in environmental conditions. They are capable of migrating long distances to maximize prey availability and can prey upon various trophic levels during their daily vertical migrations. Additional information on the life history and habitat of swordfish can be found in Chapter 6, HMS Essential Fish Habitat Provisions.

When ICCAT's Standing Committee on Research and Statistics (SCRS) scientists assess the status of Atlantic swordfish, the stock is split between the north Atlantic, south Atlantic, and Mediterranean Sea; a total Atlantic stock hypothesis is also examined. There is considerable uncertainty in stock structure. SCRS continues to examine existing information, including spawning data, tagging information, genetic studies, and abundance indices. For the purposes of domestic management, the swordfish population is considered to consist of two discrete stocks divided at 5° N. This FMP contains management measures for the north Atlantic stock only, managed under the dual authority of the Magnuson-Stevens Act and ATCA. South Atlantic swordfish are managed domestically under the authority of ATCA.

The status of both the north and south Atlantic swordfish stocks was assessed most recently in 1996 using both non-equilibrium stock production models and virtual population analysis based on international catch and catch per unit effort data through 1995. The 1996 assessment indicated that the north Atlantic swordfish stock had continued to decline despite reductions in total reported landings from peak values in 1987. The biomass at the beginning of 1996 was estimated to be 58 percent of the biomass needed to produce maximum sustainable yield (80 percent confidence interval: 41 to 104 percent). The 1995 fishing mortality rate was estimated to be 2.05 times the fishing mortality rate at maximum sustainable yield (80 percent confidence interval: 1.07 to 3.82). In 1996, the replacement yield for north Atlantic swordfish was estimated to be about 11,300 mt ww, while maximum sustainable yield was estimated to be 13,000 mt ww (80 percent confidence interval: 5,300 to 16,500 mt ww). Reported catches of north Atlantic swordfish totaled 12, 961 mt ww in 1996. SSB/SSB_{MSY} was estimated to be 0.25 (80 percent confidence interval: 0.22 to 0.29). These estimates were calculated by SCRS based on catch data through the 1995 calendar year; the next stock assessment will take place in September 1999 and will consider catch data through the 1998 calendar year.

Until the new assessment is completed in 1999, the best scientific information available for projecting the future status of swordfish stocks is contained in the 1996 assessment. The swordfish rebuilding projections in section 3.4.2 are based on 1999 as the first year of the "new" rebuilding quotas in the following analyses. Data updated since the 1996 assessment indicate similar trends to those in recent years with the exception of an increase in recruitment in 1997. This improvement could allow for a more optimistic outlook in the 1999 assessment if this year class is not heavily harvested until after it reaches spawning size (SCRS, 1998). SCRS has been tasked with developing rebuilding plans with a 50- percent probability of rebuilding within five, ten, and 15 years and/or other appropriate times. The rebuilding plans should include scheduled assessments of progress toward accomplishing the rebuilding goals. NMFS has listed north Atlantic swordfish as overfished because the fishing mortality rate is higher than that required to keep a population at maximum sustainable yield and because biomass is so low.

While not as drastic, the status of the south Atlantic swordfish stock indicates similar signs of overfishing. A quantitative assessment of the south Atlantic stock in 1996 indicated that although the biomass was estimated to be at 99 percent of that needed to produce maximum sustainable yield, the 1995 fishing mortality rate was approximately 1.24 times the fishing mortality rate at maximum sustainable yield. Reported landings in 1995 (20,600 mt) and 1996 (18,000 mt) exceeded the estimated replacement yield of 14,600 mt, thus SCRS determined that it was likely the stock would decline further. If a total Atlantic stock was assumed, it is unlikely that the outlook for stock status would be improved (SCRS, 1998). ICCAT's Standing Committee on Research and Statistics plans to conduct an assessment of the south Atlantic swordfish stock along with that of the north Atlantic stock in September 1999. NMFS seeks to reduce fishing mortality rates which should increase biomass in the long term and once rebuilt, sustain a healthy number of spawning age swordfish in these populations.

2.3.2 International Aspects of the Atlantic Swordfish Fishery

The two distinct management units for swordfish in the Atlantic Ocean, north and south, are divided at 5° N. Directed longline fisheries in the Atlantic have been operated by Spain, the United States, and Canada since the late 1950s or early 1960s. The Japanese tuna longline fishery started in 1956 and has operated throughout the Atlantic since then, with substantial bycatch of swordfish. There are other directed swordfish fisheries (e.g., Brazil, Portugal, Venezuela, Morocco, and Uruguay) and longline fisheries that take swordfish primarily as bycatch (e.g., Chinese-Taipei, Korea, and France). There is no foreign fishing for Atlantic swordfish in U.S. waters.

ICCAT established the first total allowable catch for the north Atlantic in 1991. Subsequent decreasing quotas were established for 1992 to 1997, although reported catch from 1989 to 1996 averaged 16,000 mt, well above replacement yield. In response to a 1996 stock assessment indicating that biomass was only 58 percent of that needed to support maximum sustainable yield, ICCAT further reduced north Atlantic quotas for 1997 through 1999, although the TAC still exceeded replacement yield. In 1997, SCRS determined that the failure to achieve significant overall reductions in north Atlantic fishing mortality, due in part to non-compliance by some fishing nations, had resulted in the need for more severe reductions in the future to achieve the recovery of this over-exploited species. ICCAT has also taken steps in recent years to improve compliance with existing conservation and management measures (see Section 1.1.4).

Since 1996, the major ICCAT-member swordfish harvesting nations, including the United States, have decreased their north Atlantic swordfish landings in response to ICCAT recommendations that establish catch quotas as shown in Table 2.25. Reduced landings of north Atlantic swordfish can be attributed, in part, to movement of some vessels out of the north Atlantic and into the south Atlantic or other waters. In addition, some fleets, including vessels from the United States, Spain, and Canada, have redirected effort to tuna and/or sharks to take advantage of market conditions and higher relative catch rates. There are some developing swordfish longline fisheries, including South Africa and several Caribbean nations. ICCAT remains concerned about the unreported catches of non-member countries and flag-of-convenience fleets, and the negative effects these catches may be having upon the swordfish stocks.

Table 2.25 Reported catches of north Atlantic swordfish, 1997. (SCRS, 1998)

Country	**1997 Catch in mt ww**	**Percent of Total Catch ***
Spain	5,137	40%
United States (landings)	2,988	27%
United States (discards)	446	
Japan	1,437	11%
Canada (landings)	1,089	8%
Canada (discards)	5	
Portugal	903	7%
Other Countries	965	7%
TOTAL (All Countries)	**12,970**	**100%**

* These are calendar year landings as reported to SCRS for stock assessment purposes. The United States implements swordfish quotas for a fishing year of June 1 - May 31.

A recent trend in the pelagic longline fishery for swordfish has been the expansion of fishing effort in the Caribbean Sea island nations, including Barbados, Trinidad and Tobago, Antigua, Grenada, and the British Virgin Islands, which have been exporting swordfish in increasing numbers to the United States. This is due, in part, to an increased emphasis on fisheries development by the Caribbean nations. Part of this increase may also be attributable to fishermen, including U.S. fishermen, either re-flagging their vessels or landing swordfish in the Caribbean for export to the United States (SAFMC, 1990). The consequences of re-flagging vessels, shifting targeted fishing grounds, offloading in foreign countries, and other dynamic characteristics of the pelagic longline fishery, will have to be addressed by domestic and international management entities.

Swordfish landings reported in the south Atlantic were relatively low (generally less than 3,750 mt dw) until the 1980s. The discovery of underutilized swordfish stocks in the south Atlantic Ocean by coastal state and distant water vessels resulted in increased landings through the 1980s and 1990s to a peak of 20,607 mt dw in 1995. With this increase in effort in the south Atlantic, the total Atlantic reported catch of swordfish (including discards) reached a historical high of 37,330 mt in 1995, while the estimated replacement yield is only 14,600 mt. As in the north Atlantic fishery, compliance among contracting and no-contracting parties is a concern. Preliminary analyses from SCRS have indicated that south Atlantic catches are not sustainable. In 1996, ICCAT established a 14,620 mt total allowable catch and country quotas for 1998 to 2000 in the south Atlantic fishery as shown in Table 2.26.

Table 2.26 Atlantic-wide catch of south Atlantic swordfish, 1997. (SCRS, 1998)

Country	1997 Catch in mt ww	Percent of Total Catch *
Spain	8,461	48%
Brazil	4,100	23%
Chinese-Taipei	1,847	11%
Japan	1,365	8%
Uruguay	760	4%
Portugal	441	3%
United States (landings)	396	2%
United States (discards)	21	
Other Countries	174	1%
TOTAL (All Countries)	**17,565**	**100%**

* These are calendar year landings as reported to SCRS for stock assessment purposes. The United States implements swordfish quotas for a fishing year of June 1 - May 31.

2.3.3 Domestic Aspects of the Atlantic Swordfish Fishery

Commercial Fishery

U.S. commercial swordfish fishing in the Atlantic Ocean is reported to have begun in the early 1800s as a harpoon fishery off the coast of New England. Only large fish that finned on the surface were available to the gear, some weighing as much as 600 lbs dw, but averaging about 225 to 300 lbs dw at the turn of the century. Because of the limited effort directed towards large fish, the stock was sufficient to support a sustainable seasonal swordfish fishery for more than 150 years. Most swordfish caught in the United States in the early 1900s were harvested with harpoons; harpoon landings declined from the 1940s through the 1960s.

In the early 1960s, domestic and international pelagic longline vessels began to target swordfish throughout the north Atlantic Ocean. Swordfish were targeted particularly during their annual migration along the Canadian and U.S. Atlantic coast from spawning areas in the Caribbean Sea and Gulf of Mexico to feeding areas off New England and Canada. Landings declined following a 1971 decision by the U.S. Food and Drug Administration (FDA) to limit the acceptable mercury content to 0.5 parts per million (ppm) for all swordfish landed or imported into the United States. The negative publicity concerning mercury levels had a significant impact on domestic and world swordfish demand. The FDA regulation was challenged in court in 1978, and based on more detailed analyses of seafood consumption patterns, the acceptable level of mercury was raised to 1.0 ppm (SAFMC, 1985). As consumers' fear of mercury contamination waned, average annual U.S. catches of swordfish increased to support the renewed demand (Lipton, 1986). The FDA continues to monitor mercury levels in imported swordfish.

In 1991, there were 586 vessels permitted in the U.S. fishery for Atlantic swordfish; by 1995, over 1,200 U.S. vessels had applied for permits. In July 1995, NMFS announced its intent to implement a limited access system, based on historical participation in the fishery, that would eliminate some of this latent effort. By 1997, there were 900 U.S. vessels left in the fishery, some holding a permit only in case of incidental swordfish landings. Only 315 of these vessels landed one or more swordfish in 1997. Fishing effort by pelagic longline vessels has varied since 1992. Table 2.27 indicates the number of hooks, the number of longline sets, and the number of vessels that participated in this fishery based on pelagic logbook data. As part of this FMP, NMFS has implemented a limited access system in the swordfish fishery; approximately 198 permit holders will be eligible for directed permits under the qualification criteria. Approximately 218 vessels that meet a lower threshold of historical landings will qualify for an incidental permit (See Chapter 4).

Table 2.27 Fishing effort in the Atlantic pelagic longline fishery 1992 - 1997.

Year	# of Hooks	# of Sets	# of Vessels
1992	8,351,250	15,458	279
1993	8,485,366	14,691	299
1994	9,046,432	15,257	284
1995	10,114,866	15,929	300
1996	10,612,835	16,763	273
1997	9,054,966	14,248	251

The U.S. directed fishery for north Atlantic swordfish is confined by regulation to two gear types: longline and handgear. Pelagic longlining accounts for approximately 98 percent of U.S. directed swordfish landings (Table 2.28). Previously, driftnets were allocated two percent of the U.S. north Atlantic directed fishery quota. The use of driftnets in the Atlantic swordfish fishery was prohibited by NMFS in January 1999. Incidental catches by fishing gears other than pelagic longline and handgear are restricted to incidental commercial retention limits of two to five swordfish per trip depending on gear type, and are counted against the incidental catch quota. Longline fishermen may only land 15 swordfish per trip during a directed fishery closure, creating a disincentive to target swordfish. NMFS can adjust these retention limits based on the availability of incidental catch quota. Incidental landings are made by otter trawl vessels fishing for squid, mackerel and butterfish (the primary prey species sought by swordfish).

U.S. fishermen were allocated 3,277 mt ww of north Atlantic swordfish quota in 1997, 3,190 mt ww in 1998, and 3,103 mt ww in 1999. The United States has implemented a split-year fishing season of June 1 to May 31, divided into two six-month seasons, to facilitate management in response to changing quotas. In addition to quotas, all commercial and recreational fishermen must comply with a minimum size limit of 33 lb dw (119 cm lower jaw fork length, 29 inches cleithrum to keel). Commercial vessels and charter/ headboat vessels must accept on-board observers when selected, and must comply with the permitting and reporting requirements described in Section 2.6. Swordfish dealers and importers are also subject to permitting and reporting requirements.

During the 1997 fishing year (June 1, 1997, to May 31, 1998), approximately six to ten U.S. fishing vessels targeted south Atlantic swordfish. Because no part of that stock's range (south of 5° N) is in the U.S. EEZ, south Atlantic swordfish are not within the management authority of the Magnuson-Stevens Act. However, the stock and its fishery are discussed briefly in this FMP because south Atlantic swordfish are subject to ICCAT (and thus ATCA) management authority and because fishermen who fish in the south Atlantic also fish for north Atlantic swordfish. United States commercial fishermen landed less than their 250 mt ww south Atlantic swordfish quota during the 1997 fishing year. NMFS has implemented south Atlantic quotas for the fishing years 1998 through 2000, with an annual quota of 289 mt dw, negotiated through a sharing agreement. A split-year fishing season has also been implemented in the south Atlantic Ocean, in combination with other management measures comparable to those in the north Atlantic (permitting, reporting, observers, etc.).

Table 2.28 U.S. catches of Atlantic swordfish for calendar years 1995 - 1997 in mt ww. (SCRS, 1998; National Report of the United States, 1998)

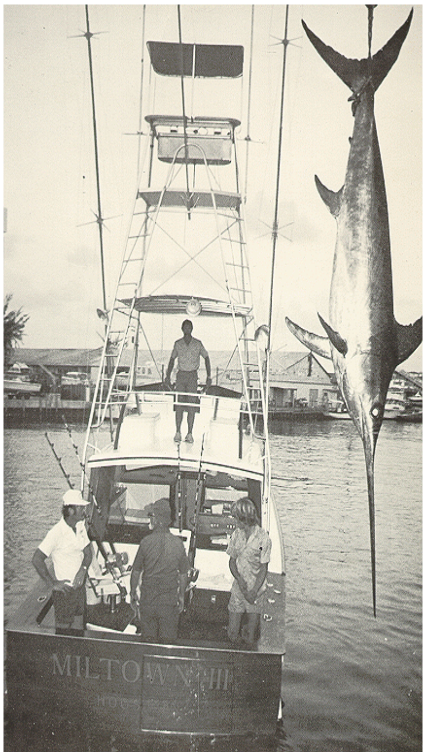
Area	Gear	1995	1996	1997
NW Atlantic	Longline	988.4	954.2	1,008.4
	Longline Discards	292.2	356.2	253.8
	Driftnet	74.0	77.8	0.4
	Pair Trawl	14.6	0.0	0.0
	Handline	0.0	0.1	1.3
	Trawl	9.8	19.8	8.0
	Troll		7.3	0.4
	Unclassified Discards		6.8	11.9
	Harpoon	1.0	0.5	0.7
Gulf of Mexico	Longline	597.6	780.4	650.5
	Longline Discards	43.5	115.9	109.4
Caribbean	Longline	1,575.7	1,137.0	671.3
	Longline Discards	65.7	45.8	17.6
NC Atlantic	Longline	764.0	585.0	635.2
	Longline Discards	124.3	44.4	53.0
SW Atlantic	Longline		171.2	396.5
	Longline Discards		1.4	21.4
TOTAL	**All Gears**	**4,550.8**	**4,320.1**	**3,839.7**

Recreational/Charterboat Fishery

The swordfish recreational fishery has existed along the Atlantic coast since the 1920s, when small vessels caught swordfish off Martha's Vineyard and Nantucket by trolling. Prior to 1967, approximately 50 swordfish were caught annually with rod and reel in about 1,000 attempts from Massachusetts to Long Island (SAFMC, 1985). During the 1970s, recreational fishing for swordfish expanded all along the Atlantic coast due to new techniques and the development of night fishing (SAFMC, 1985). Tournaments were held in a number of states including South Carolina and New Jersey in 1978 and in Florida from 1977 through 1983. The recreational fishery began to decline in 1978 due to decreasing catch rates (SAFMC, 1985).

There are minimal data available on current rod and reel fishing for swordfish. The Marine Recreational Fisheries Statistics Survey did not encounter any recreational fishermen who caught a swordfish from 1994 to 1997, although 242,943 boat angler trips were randomly sampled along the Atlantic and Gulf Coasts during this time. In 1996, two swordfish were reported to the Large Pelagic Survey and retained by the fishermen. In 1997, 16 swordfish were reported to the Large Pelagic Survey; ten were retained by the fishermen and six were released alive. In 1998, six swordfish were reported to the Large Pelagic

Survey; one was retained and five were released alive. Over this three-year period, most of the swordfish documented by the Large Pelagic Survey were caught by anglers in New Jersey and New York. Percentages of the Large Pelagic Survey dockside intercepts are indicative of the percentages of vessel trips targeting large pelagics that encounter swordfish. For example, the Large Pelagic Survey dockside sampling data indicate that less than 0.2 percent of all vessel trips targeting large pelagic species with a hook and line or handline actually landed a swordfish in 1997.



"An exciting new recreational fishery for swordfish has developed over the past couple of years" – Oceanic Game Fish Newsletter, 1978. Photo credit: NOAA

Based on NMFS tournament data, swordfish are rarely encountered in tournaments targeting billfish or other HMS. For example, in tournaments taking place along the Atlantic coast of Florida and the Florida Keys in 1994 to 1995, no swordfish were caught in 18,566 hours of fishing effort (NMFS, 1997d). The Cooperative Tagging Center at the Southeast Fisheries Science Center occasionally encounters swordfish entries, although they are considered rare event species caught incidental to other trolling recreational fisheries. There are anecdotal reports of recreational fishermen catching swordfish. Fishermen have reported catching swordfish in the Hudson Canyon at night during the summer of 1997.

Because the recreational fishery has encountered so few Atlantic swordfish in recent years, it was exempt from U.S. swordfish quotas prior to the implementation of this FMP. One objective of this FMP is to rebuild the swordfish stock such that recreational fishermen may enjoy an enhanced recreational experience through higher interactions with swordfish. All recreational swordfish landings are now subtracted from the U.S. Incidental quota, and this mortality is reported to ICCAT.

2.3.4 Social and Economic Aspects of the Domestic Atlantic Swordfish Fishery

Commercial Fishery

Many consumers consider swordfish to be a premier seafood product. Swordfish that may bring $3.00 per pound to the vessel may the sell in some restaurants at prices of $30.00 for a six-ounce steak. Swordfish prices are affected by a number of factors, including the method of harvest, either by distant-water or inshore vessels, and by gear type; harpoon vs. pelagic longline. Generally, prices for fresh swordfish can be expected to vary during the month due to the heavier fishing effort around the period of the full moon. Swordfish prices also vary by size and quality, with prices first increasing with size, up to about 250 lbs, then decreasing due to higher handling costs for larger fish. "Marker" swordfish weighing 100 to 275 lbs are preferred by restaurants because uniform-sized dinner portions can be cut with a minimum of waste. Pups weighing 50 to 99 lbs dw are less expensive than markers but the yield of uniformly sized portions is smaller. "Rats" (33 to 49 lbs dw) are the least expensive but are generally not used by food service or retail buyers who require large portions of uniform size.

Although ICCAT quotas for Atlantic swordfish have decreased, U.S. prices have actually declined over the past four years (Table 2.29). The combination of decreased prices and decreased quota indicates that total gross revenues for the fleet as a whole have probably declined as well. Declining prices for swordfish may be the result of substitution with imports which occur during critical months of the year; imports of swordfish have increased dramatically in recent years. The relatively strong U.S. dollar and weak Japanese yen may be drawing fish that were formerly marketed in Asia to the domestic market, including swordfish and steak-grade tuna that compete with U.S. domestic swordfish. NMFS has also received anecdotal reports of decreasing prices for swordfish due to a campaign supporting the short-term boycott of swordfish until a rebuilding plan is in place, sponsored by a consortium of marine conservation organizations.

Table 2.29 Index of ex-vessel prices for swordfish, 1989 - 1997. Base year is 1982. (Fisheries of the United States, 1997)

Year	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**
Index	119	108	102	111	92	107	104	103	91

Studies demonstrate that ex-vessel gross revenues may rise as supply decreases and as U.S. consumer income rises (Gauvin 1990; Thunberg and Seale, 1992). Demand for swordfish was shown to be stronger during the second and third quarters of the year (Thunberg and Seale, 1992), reflecting the popularity of swordfish steaks during the barbecue and seaside tourist seasons. Other factors, such as changes in the fleet in location and in targeted species (from swordfish to bigeye and yellowfin tuna) also affect the dynamics of the fishery. Further, closure dates due to quota limits may cause market gluts and the resulting low prices. Preliminary analyses conducted by NMFS since proposing limited access indicate that approximately a third of current permit holders are substantially dependent on the swordfish fishery (see Chapter 4).

There are currently 213 dealers who are permitted to buy Atlantic swordfish from U.S. commercial fishermen; 148 of them are located in the Southeast (NMFS, 1998). About 12 swordfish dealers also import swordfish. NMFS has extended dealer permitting and reporting requirements to all swordfish importers as well as dealers who buy domestic swordfish from the Atlantic. NMFS has identified about 200 swordfish importers. Dealers submit reports to NMFS on swordfish sales that include the weight and price of the fish. All but 15 of the 213 Atlantic swordfish dealers also have dealer permits for other species and are therefore probably not completely dependent upon their swordfish sales. Swordfish dealers are located along the Atlantic and Gulf coasts and in the Caribbean.

Swordfish carcasses are inspected by NMFS Office of Law Enforcement personnel. Photo credit: Louis Jachimczyk, NMFS.

NMFS finalized regulations in March 1999 that enhance tracking of swordfish trade, including dealer permitting and reporting requirements for all swordfish importers, a documentation strategy that indicates the ocean of origin and flag of the harvesting vessel, and a prohibition of the import of all Atlantic swordfish weighing less than the U.S. minimum size of 33 pounds. Information collected in the past did not provide accurate data regarding the harvesting country as vessels may offload in a port other than their home port due to distant water fishing trip for swordfish, such that the exporting country may not be the same as the harvesting country. Therefore, it is difficult to track swordfish trade activities against ICCAT quotas with great precision.

The processing and wholesale sectors are an integral part of the U.S. swordfish industry. The primary processing sector includes firms that purchase the raw product from fishermen or importers and transform it into a consumer product. Secondary processors provide restaurants and food service distributors with loins or "wheels" (large bone-in sections cut through the body). In 1995, U.S. processors handled 4,549 tons of fresh or frozen swordfish valued at $53.4 million. Fillets accounted for 2,920 tons valued at $36.5 million while steaks were 1,629 tons worth $16.9 million (Folsom *et al.*, 1997). There are over 350 seafood processors along the Atlantic coast of the United States; approximately 50 of these processors are active in the swordfish fishery (Folsom *et al.*, 1997; Beideman, N., BWFA, Barnegat Light, NJ, pers. comm.). Employment varies widely among processing firms. The average firm employs less than 40 people and employment may be seasonal due to the nature of some fisheries. Most of these firms handle other species as well, reflecting the multi-species nature of the pelagic longline fishery.

Other participants involved in the commercial trade sector of the Atlantic swordfish fishery include brokers, freight forwarders, carriers (primarily commercial airlines), and consignees. Brokers are private individuals or companies who are hired by importers and exporters to help move their merchandise through U.S. Customs with the proper paperwork and payments. The broker must possess thorough knowledge of tariff schedules and U.S. Customs regulations and keep abreast of changes in the law and administrative regulations. Freight forwarders often arrange for land transportation and storage facilities for the incoming shipment. The nominal or an ultimate consignee is the person who "owns" the shipment of swordfish. From July through December 1997, there were 231 firms that were listed as consignees on entry summary forms for 4,563 swordfish shipments. These consignees were from 18 states, Guam, and six foreign countries.

Swordfish is an important commodity on world markets, generating in excess of $100 million in export earnings in recent years (Folsom *et al.*, 1997). Swordfish trade statistics are tracked using separate product codes reported by importers on U.S. Customs forms. Import activity has followed fluctuations in supply and consumer demand for the product during the past several decades. A sharp rise in recent swordfish imports may be due in part to the use of specific swordfish product codes on import forms, but is likely due to a combination of factors, including increased consumer interest in imported swordfish. Swordfish imports generally increase throughout the summer and peak in August or September.

Swordfish was imported into the United States from 37 countries in 1998. Seventy-seven percent of that swordfish (by weight) was exported from nations that are not members of ICCAT. Fifty-three percent of imported swordfish (steaks and other products combined) was fresh (8,572 mt) in 1998. Chile, Brazil, Australia, and Canada were major sources of U.S. fresh swordfish imports in 1998. Of the 7,677 mt imported in frozen product, 94 percent (by weight) comes in as frozen fillets. Eighty-five percent (by weight) of all imported frozen swordfish comes from Singapore. Swordfish was imported into 14 U.S. ports in 1998, with Miami, FL as the principal port of entry in terms of the number of shipments, and Los Angeles, CA the principal port by weight (Figures 2.1 and 2.2).

Figure 2.1 Swordfish Ports of Entry, 1998 (by number of shipments)

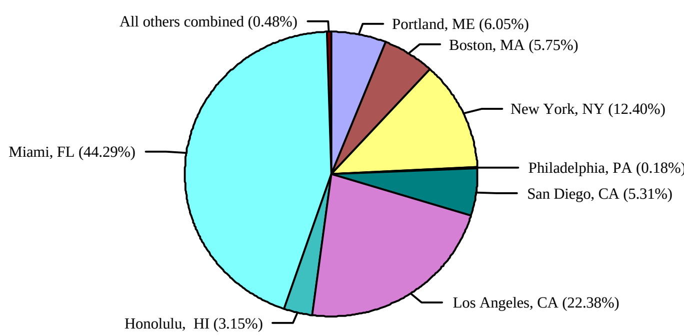
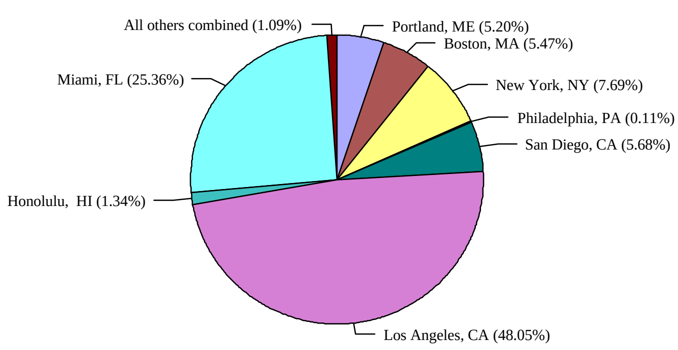


Figure 2.2 Swordfish Ports of Entry, 1998 (by weight)



Charter/Headboat Fishing

While few anglers are now targeting Atlantic swordfish, the recreational fishery was active in the 1980s. At that time, recreational anglers spent between $200 and $800 for an overnight fishing trip, depending on region and proximity to fishing grounds (SAFMC, 1985). Generally, swordfishing grounds are 70 to 100 miles offshore along much of the Atlantic coast, making the costs for recreational fishing for swordfish much higher than for most other species (SAFMC, 1985). As the north Atlantic stock rebuilds so that swordfish are more available, recreational anglers' catch rates are likely to increase, and tournaments may again include swordfish on their list of prized gamefish. Given that swordfish are found so far offshore, the revival of this recreational fishery would most likely lead to increased fishing opportunities and economic benefits for the charterboat industry, as well as benefits to the coastal communities where recreational fishing occurs. Reports from anglers along the mid-Atlantic coast during 1998 indicate rising rates of swordfish interactions.

2.4 Atlantic Sharks

2.4.1 Life History and Status of the Stocks

Sharks belong to the class Chondrichthyes (cartilaginous fishes) that also includes rays, skates, and deepwater chimaeras (ratfishes). From an evolutionary perspective, sharks are an old group of fishes characterized by skeletons lacking true bones. The earliest known sharks have been identified from fossils in the rocks of the Devonian period, over 400 million years ago. These primitive sharks were small creatures, about 60 to 100 cm long, that were preyed upon by larger armored fishes that dominated the seas. Sharks have survived competition for eons, evolving into the large and aggressive predators that dominate the seas today. The life span of sharks in the wild is not known, but it is believed that many species may live 30 to 40 years or longer.

Since sharks have evolved primarily as apex predators, they are not equipped to withstand predation themselves - especially in the form of intense exploitation. Relative to other marine fish, sharks have a very low reproductive potential. Several important commercial species, including large coastal carcharhinids such as sandbar (Casey *et al*., 1985; Sminkey and Musick, 1995; Heist *et al*., 1995), lemon (Brown and Gruber, 1988), and bull sharks (Branstetter and Stiles, 1987), do not reach maturity until 12 to 18 years of age. Various factors determine this low reproductive rate: slow growth, late sexual maturity, one- to two-year reproductive cycles, a small number of young per brood, and specific requirements for nursery areas. These biological factors leave many species of sharks vulnerable to overfishing.

There is extreme diversity among the 350 species of sharks, ranging from tiny pygmy sharks of only 20 cm in length to the giant whale sharks, over 12 meters in length. There are fast-moving, streamlined species such as mako and thresher sharks, and sharks with flattened, ray-like bodies, such as angel sharks. The most commonly known sharks are large apex predators including the white, mako, tiger, bull, and great hammerhead. Some shark species reproduce by laying eggs, others nourish their embryos through a placenta. Despite their diversity in size, feeding habits, behavior and reproduction, many of these adaptations have contributed greatly to the evolutionary success of sharks.

Sharks are generally aggressive predators feeding near the top of the food web. They have extremely sensitive smell receptors, eyes that can adapt to dim light, lateral line receptors that sense movement in the water, and electroreceptors that can detect prey buried in the sand even in the absence of scent or visual clues. In addition to their finely-tuned senses, sharks are armed with a formidable set of teeth and jaws. The teeth are replaced often, so sharks always have a sharp set capable of inflicting a clean bite. The tiger shark eats large turtles, and the tiny cookiecutter shark feeds by carving plugs of flesh out of large fishes and whales. Only basking sharks, whale sharks, and megamouth sharks feed by filtering small organisms from the water.

The most significant reproductive adaptations of sharks are internal fertilization and the production of fully developed young or “pups.” These pups are large at birth, effectively reducing the number of potential predators and enhancing their chances of survival. During mating, the male shark inseminates the female with copulatory organs, known as claspers, that develop on the pelvic fins. In most species, the embryos spend their entire developmental period protected within their mother’s body, although some species lay eggs. The number of young produced by most shark species in each litter is small, usually ranging from two to 25, although large females of some species can produce litters of 100 or more pups. The production of fully-developed pups requires great amounts of nutrients to nourish the developing embryo. Traditionally, these adaptations have been grouped into three modes of reproduction: oviparity, ovoviviparity, and viviparity.

Oviparity is the most primitive condition, although it is still different from the reproductive strategy of bony fishes. Oviparous sharks lay large eggs that contain sufficient yolk to nourish the embryo and allow it to emerge fully developed. These eggs are enclosed in leathery cases that are deposited on the sea bottom, usually attached to plants or rocks. There is no parental care or brooding in sharks. The only protection for the embryo is its tough leathery case, composed of protein fibers. The development of these eggs is temperature-dependent and hatching usually occurs in a few months to a year. The pups of oviparous sharks are somewhat small because their growth is limited by the amount of nutrients stored in the egg. The embryos of the oviparous whale shark, the largest living fish, measure only 36 cm. Oviparity is found in four families of sharks: bullhead sharks (*Heterodontidae*), cat sharks (*Scyliorhinidae*), whale sharks (*Rhinocodontidae*), and some species of nurse sharks (*Ginglymostomatidae)*.

Ovoviviparity, also known as aplacental viviparity, is the most common mode of reproduction in sharks. The eggs of ovoviviparous sharks hatch in the uterus before the embryos are fully developed. The embryos continue to grow in the uterus, nourished by the yolk sac, without forming a placental connection with the mother. The size of the litter is highly variable, depending on the reproductive strategy of the species. In some ovoviviparous sharks, such as the sand tiger, the yolk is absorbed very early in development. Thereafter, the embryos nourish themselves by swallowing unfertilized eggs and smaller embryos in the uterus, in a form of embryonic cannibalism called oophagy. Having eaten its smaller siblings, usually only one embryo survives in each of the two uteri. Ovoviviparous sharks include cow, frill, sand tiger, goblin, mackerel, basking, thresher, false cat sharks, saw, angel, squaloid, some nurse sharks, some smooth dogfishes, and some cat sharks.

Viviparity, or placental viviparity, is the most advanced mode of reproduction. The embryos of viviparous sharks are initially dependent on stored yolk but are later nourished by the mother through a placental connection. Once connected to the blood supply of the mother, the embryo has an abundant and continuous supply of nutrients. The embryo can thus be nurtured to a relatively large size at birth. Most placental sharks produce broods of two to a dozen, with a few exceptional pelagic species producing 20 to 40 young. Smooth dogfishes, requiem sharks, and hammerheads are all viviparous sharks.

In spite of the diversity of adaptations, sharks generally have a low reproductive potential. Most species of sharks have gestation periods and ovarian cycles that each last about a year. These two cycles may or may not run concurrently. In most of the larger carcharhinid sharks, the cycles follow sequentially. Most of these species reproduce only once every two years. In other species, such as hammerheads and sharpnose sharks, the ovarian cycle and the gestation periods run concurrently. Females carry developing embryos and developing eggs at the same time; these species reproduce yearly. Other species have even longer gestation periods. The spiny dogfish has a gestation period of about 24 months, the longest known of any living vertebrate.

Adults usually congregate in specific areas to mate and females travel to specific nursery areas to pup. These nurseries are discrete geographic areas, usually in waters shallower than those inhabited by the adults. Frequently the nursery areas are in highly productive coastal or estuarine waters where abundant small fishes and crustaceans provide food for the growing pups. These areas also may have fewer large predators, thus enhancing the chances of survival of the young sharks. In temperate zones, the young leave the nursery with the onset of winter; in tropical areas, young sharks may stay in the nursery area for a few years.

Shark habitat can be described in four broad categories: 1) coastal, 2) pelagic, 3) coastal-pelagic, and 4) deep-dwelling. Coastal species inhabit estuaries, the nearshore and waters of the continental shelves, e.g., blacktip, finetooth, bull, lemon, and sharpnose sharks (which are thought to enter wetland tidal creeks). Pelagic species, on the other hand, range widely in the upper zones of the oceans, often traveling over entire ocean basins. Examples include mako, blue, and oceanic whitetip sharks. Coastal-pelagic species are intermediate in that they occur both inshore and beyond the continental shelves, but have not demonstrated mid-ocean or transoceanic movements. Sandbar, scalloped hammerhead, and dusky sharks are examples of coastal-pelagic species. Deep-dwelling species, e.g., most cat sharks and gulper sharks, inhabit the dark, cold waters of the continental slopes and deeper waters of the ocean basins. For additional information on the life history and habitat of each shark species in the management unit, see Chapter 6, HMS Essential Fish Habitat Provisions.

Seventy-three species of sharks are known to inhabit the waters along the U.S. Atlantic coast, including the Gulf of Mexico and the waters around Puerto Rico and the U.S. Virgin Islands. Seventy-two species are managed under this FMP; spiny dogfish also occur along the U.S. coast, however management for this species is under the joint authority of the New England and Mid-Atlantic Fishery Management Councils (see Chapter 1). Based on a combination of ecology and fishery dynamics the sharks in the management unit have been divided into five species groups for management: 1) large coastal species, 2) small coastal species, 3) pelagic species, 4) prohibited species, and 5) deepwater/other species (see Chapter 1 and Section 3.4.2.3.1 for the classification of species.)

2.4.1.1 Large Coastal Sharks

The most recent Shark Evaluation Workshop (SEW) for the species included in the large coastal sharks (LCS) management unit was held in June 1998 (for Executive Summary, see Appendix 4). All known sources of mortality were accounted for, including dead discards and state landings after federal closures. Through this final FMP and its implementing regulations, dead discards and state landings after federal seasons are counted against federal quotas. The 1998 SEW presented updated catch and catch rate information (Tables 2.30, 2.31, 2.32, 2.33 and Figure 2.3), the results of several population modeling papers, an analysis of the effectiveness of the recreational retention limits, several studies delineating shark nursery and pupping grounds, and data on shark catches and species composition in Mexican fisheries. As in previous SEWs, several population modeling approaches were used due to the uncertainties in the data and because the models had various strengths and weaknesses such that all provide useful information. The 1998 SEW attempted to integrate several population modeling approaches, including demographic methods, catch rate data, and production modeling within a Bayesian framework.

Due to concerns that the catch series for large coastal sharks from the mid 1980s to the early 1990s substantially underestimates mortality from the commercial fishery, the 1998 SEW conducted "baseline catch" series (unadjusted reported catches) as well as "alternative catch" series analyses to assess the sensitivity of the population models to changes in the catch series. Additionally, due to concerns that management of species aggregates can result in excessive regulation on some species and excessive risk of overfishing on others, the 1998 SEW developed and analyzed both the baseline and alternative catch histories of the two primary commercial and recreational species, sandbar and blacktip sharks, separately. Sandbar shark catches did not include an estimate of Mexican catches because sandbar sharks comprise only 0.6 percent of landings (by number) in Mexican artisanal fisheries, which are thought to account for 80 percent of shark production in the Mexican Gulf, and because only seven percent of all tagged sandbar shark returns are from Mexico (Castillo and Marquez, 1996; Bonfil, 1997; Castillo *et al.*, 1998), suggesting that these landings are not a major source of mortality. Both the baseline and alternative catch series for blacktip sharks included estimated Mexican catches due to the belief that blacktip sharks from the western Gulf of Mexico are caught in both Mexican and U.S. waters (blacktip sharks comprise 11 percent of shark landings in Mexican artisanal fisheries, see Castillo *et al.*, 1998).

When large coastal shark were considered as an aggregate, the results were considerably more pessimistic than when the analyses considered sandbar and blacktip sharks separately. The mean estimates for large coastal shark indicate a slowing of the decrease in stock size in recent years; whereas, the means for sandbar sharks show stabilization and perhaps an increase in recent years. Variability in the blacktip shark results dominates any signal from these analyses. The alternative catch analyses of the large coastal and blacktip sharks were not substantially different from the baseline results; however, the alternative catch analyses of the sandbar shark resulted in the most optimistic projection with a 50 percent probability that sandbar sharks could rebuild to maximum sustainable yield within ten years under 1997 quota levels. However, the 1998 SEW Report states "[r]ecovery to MSY is likely to be a lengthy process under the best of circumstances, and it is unlikely that full recovery of the resource to MSY stock level could occur within a decade under any catch scenario" (p. 30).

In the analysis of the catch rate series, the SEW found that for large coastal sharks during the period 1993 to 1997, three of seven catch rate indices exhibit negative slopes (two of which are statistically significant) and four indices exhibit positive slopes (one of which is statistically significant). The largest annual rate of increase from these indices during this period was 17 percent, while the largest decrease was 29 percent (Table 2.33).

For the large coastal sharks baseline catch series, results of the Bayesian model indicate that: the stock size had continuously declined from about 8.9 million fish in 1974 to about 1.4 million fish in 1998; the maximum sustainable catch (MSC) was 149,063 fish; the stock size in 1998 was only about 15 percent of carrying capacity or 30 percent of maximum sustainable yield levels; the landings in 1997 were about 2.2 times that which would produce maximum sustainable catch; and the 1997 fishing mortality rate was over six times higher than that which would produce maximum sustainable yield (Table 2.34). Projections indicate that the status quo policy (50 percent reduction in 1995 quota) would not allow recovery of the stock (Nfin/K = 0.01 after ten, 20, and 30 years), with negligible probability that stock size after ten, 20, and 30 years would be larger than the 1998 stock size. The zero-landings policy indicated that the stock would reach the maximum sustainable yield level (Nfin/K = 0.5) only after 30 years, with an associated probability of stock size after 30 years being larger than the maximum sustainable yield level (Nfin greater than 0.5K) of 46 percent (see Chapter 3).

For the large coastal sharks alternative catch series, results indicate that the stock size had continuously declined from about 11.3 million fish in 1974 to about 2.1 million fish in 1998; maximum sustainable catch was 142,766 fish; the stock size in 1998 was only about 18 percent of carrying capacity or 36 percent of maximum sustainable yield levels; the landings in 1997 were about 2.3 times that which would produce maximum sustainable catch; and the 1997 fishing mortality rate was over six times higher than that which would produce maximum sustainable yield (Table 2.34). Predictions under this scenario incorporating expanded landings did not differ much from the baseline catch series scenario. In addition to the zero-landings policy, which indicated that the stock would almost reach the maximum sustainable yield level (Nfin/K = 0.47) only after 30 years, the ten percent of 1995 quota policy also showed a slowly recovering trajectory, with stock size as a proportion of K increasing from 0.22 after ten years, to 0.27 after 20 years, and to 0.34 after 30 years (see Chapter 3).

Table 2.30 Estimates of total landings and dead discards for large coastal sharks (numbers of fish in thousands). (1998 SEW Report)

Year	Column 1 Commercial Landings	Column 2 Longline Discards	Column 3 Recreational Harvest	Column 4 Unreported Landings	Column 5 Coastal Discards	Column 6 Total
1981	16.2	0.9	265.0			282.1
1982	16.2	0.9	413.9			431.0
1983	17.5	0.9	746.6			765.0
1984	23.9	1.3	254.6			279.8
1985	22.2	1.2	366.1			389.6
1986	54.0	2.9	426.1	24.9		508.0
1987	104.7	9.7	314.4	70.3		499.0
1988	274.6	11.4	300.6	113.3		699.9
1989	351.0	10.5	221.1	96.3		678.8
1990	267.5	8.0	213.2	52.1		540.8
1991	200.2	7.5	293.3	11.3		512.3
1992	215.2	20.9	304.9			541.1
1993	169.4	7.3	249.0		17.6	443.3
1994	228.0	8.8	160.9		22.8	420.5
1995	222.4	6.1	183.4		22.2	434.1
1996	164.5	5.7	184.5		16.4	371.1
1997	98.4	5.6	161.9		9.8	275.7

Column 1, commercial landings - These data are the landings reported under the established NMFS cooperative statistics program. (See Poffenberger, 1998, for a description of this data collection program.) The data are collected in landed or dressed weight. Various sources of weight per fish estimates were used to convert pounds to numbers of fish. For the period 1981 through 1985, a generic factor of 45 lbs dressed weight per fish was used. For 1986 through 1991, an average weight for all species was used. These averages are the ones that were used in the 1992 assessment. For 1992 and 1993, average weights for coastal species observed in longline catches were used in Poffenberger, 1998, but the group felt that these weights were too high to apply to fish caught nearer shore in the directed large coastal fishery. Therefore, a weight of 40 lbs per fish was used for these two years. For 1994 through 1997, predicted weights from lengths based on the observer program (Branstetter and Burgess, 1997) and data from the pelagic longline database were used.

Column 2, pelagic longline discards - The data for this column are from the analyses of the discards by pelagic longline vessels (see Cramer, 1996). The estimates prior to 1987 are calculated using the average ratio of the discards to commercial landings for the data for 1987 through 1992 (discards as a fraction of combined landings and discards averaged 5.12% over this period). A fraction of 5.12% was also assumed for the 1996 value since data to support a new estimate for 1996 are not yet available.

Column 3, recreational harvest - These data are reproduced from Scott *et al.*, 1996, and include estimated harvest from the NMFS MRFSS, headboat and charterboat surveys and the Texas Parks and Wildlife recreational creel survey. The estimate for 1996 also included harvest from the same three sources (described below).

Column 4, unreported landings - These data are from a single source, which owned a fleet of vessels that fished in the Gulf of Mexico and off the coast of North Carolina. The estimate for 1988 was determined from company landings records. The estimates for other years were prorated based on the 1988 landings record and financial statements indexing income from shark fishing (Hudson, 1998). The Working Group did not have any way of determining the amount, if any, of these landings that were included. Therefore, the Working Group made the assumption that none of the landings were included and kept these data separate, listing them as unreported. The implicit assumption in doing this is that the landings were off-loaded in Alabama docks, but not sold to Alabama dealers.

Column 5, discards by coastal fishery - These data are from the Gulf and South Atlantic Fisheries Development Foundation/University of Florida observer program (GSAFDF, 1996) and show that slightly more than 10% of large coastal species were discarded by the directed fishery in 1994 and 1995. The calculated percentages for 1994 and 1995 were averaged and applied to the recorded landings for 1993 to give an estimate of the discards in 1993. A 10% discard fraction was also assumed for 1996. The discarded species are non-marketable animals that are included in the large coastal management unit.

Column 6, total - The numbers in this column are the sum of columns 1-5

Table 2.31 Modifications to estimates of total landings and dead discards for large coastal sharks (numbers of fish in thousands), to evaluate the sensitivity of assessment models using landings data. Modifications from Table 2.30 are shown in italics. (1998 SEW Report)

Year	Column 1 Commercial Landings	Column 2 Longline Discards	Column 3 Recreational Harvest	Column 4 Unreported Landings	Column 5 Coastal Discards	Column 6 Total
1981	*24.3*	*10.0*	265.0			*299.3*
1982	*24.3*	*10.0*	413.9			*448.2*
1983	*26.2*	*10.0*	*324.6*			*360.8*
1984	*35.8*	*10.0*	254.6			*300.4*
1985	*33.3*	*10.0*	366.1			*409.4*
1986	*108.0*	*10.0*	426.1	24.9		*603.8*
1987	*209.4*	9.7	314.4	70.3		*499.0*
1988	*549.2*	11.4	300.6	113.3		*974.5*
1989	*702.0*	10.5	221.1	96.3		*1,029.9*
1990	*535.0*	8.0	213.2	52.1		*808.3*
1991	*400.4*	7.5	293.3	11.3		*712.5*
1992	*430.4*	20.9	304.9			*756.2*
1993	*254.1*	7.3	249.0		*25.4*	*535.8*
1994	228.0	8.8	160.9		22.8	420.5
1995	222.4	6.1	183.4		22.2	434.1
1996	164.5	5.7	184.5		16.4	371.1
1997	98.4	5.6	161.9		9.8	275.7

Column 1 - During the period 1981-1985, commercial landings were assumed under reported by 50% and thus the values in the baseline catch series table were multiplied by 1.5. For the period 1986-1992, commercial landings were assumed to be under reported by 100% and thus the values in the baseline catch series table were multiplied by 2. For 1993, the landings made prior to the mid-year implementation of the FMP were assumed under reported by 100% and thus the values in the baseline catch series table were multiplied by 1.5.

Column 2 - For the period 1981-1986, longline dead discards were assumed to equal 10,000 fish per year.

Column 3 - The 1983 recreational harvest estimate was assumed to be the geometric mean value of the 1982 and 1984 estimates, although there is no obvious statistical or sampling theoretical reason to consider the 1993 harvest estimate less accurate than the neighboring years estimates.

Table 2.32 Estimated landings of Large Coastal Sharks in commercial and recreational fisheries for 1996 and 1997. Note: landings of fins are included in the commercial estimate. (Scott *et al.*, 1998)

Species	**Commercial Landings** (in pounds, dressed weight)		**Recreational Harvest** (in numbers of fish)	
	1996	**1997**	**1996**	**1997**
Bignose	41,428	2,132		
Blacktip	1,703,413	1,503,356	78,010	68,284
Bull	76,052	40,247	9,670	1,254
Dusky	270,751	73,250	14,732	13,278
Great hammerhead			3,197	379
Hammerhead	172,068	62,955	1,307	618
Lemon	41,872	20,595	5,935	2,354
Night	6,421	57	379	90
Nurse	873	8,864	5,968	7,859
Reef	1,639	3,548	19	10
Sand tiger	7,433	7,920	321	1,466
Sandbar	1,609,922	863,574	35,180	40,929
Scalloped hammerhead			723	3,320
Silky	42,070	13,920	371	240
Smooth hammerhead			2,538	2,176
Spinner	55,171	6,039	6,577	3,342
Tiger	45,845	5,312	22	70
Whale		3,598		
White	1,862	1,315		
Unclassified	1,185,494	510,512	19,611	16,298
TOTAL	**5,262,314**	**3,127,223**	**184,560**	**161,967**

Table 2.33 Recent (1993 - 1997 and 1990 - 1997) trends in catch rates. Slopes and standard deviations (SD) of the slopes are expressed relative to the mean of the data points (n) in the slope calculation. Slopes that are significantly different from zero at a 0.1 probability level are marked with an *. (1998 SEW Report)

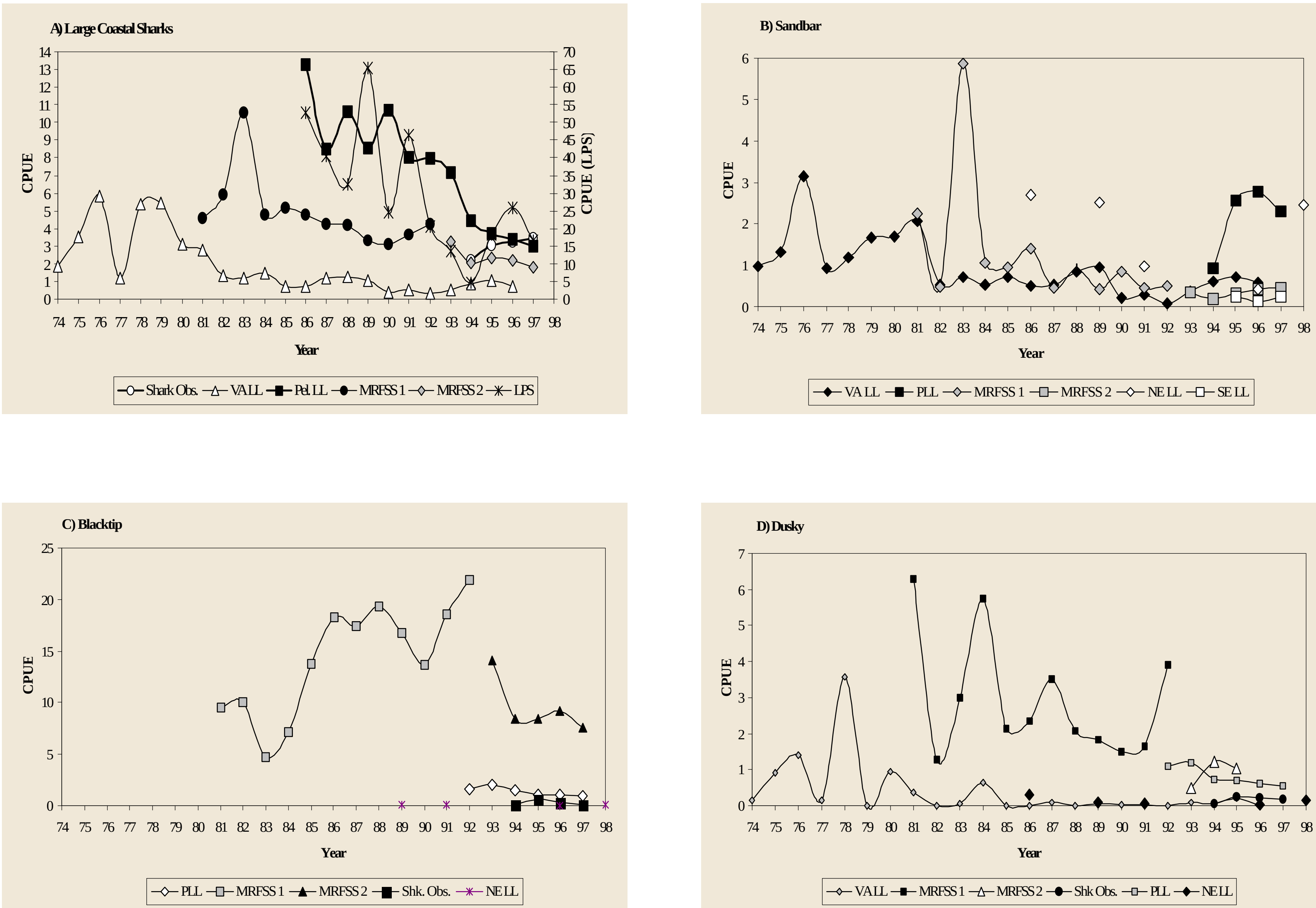
Index	1993 - 1997 Data			1990 - 1997 Data		
	n	slope	SD	n	slope	SD
Large Coastal Sharks						
Shark Observer	4	0.1367*	0.0391	4	0.1367*	0.0391
Virginia LL	4	0.0975	0.1005	7	0.1251*	0.0436
LPS	5	0.1753	0.1488	8	-0.0969	0.0867
Charterboat	3	0.0470	0.0373	6	-0.0095	0.0241
Pelagic Logs	5	-0.2160*	0.0628	8	-0.1821*	0.0203
Late Rec Surveys	5	-0.1163*	0.0515	5	-0.1163*	0.0515
NMFS LL SE	3	-0.2870	0.3999	3	-0.2870	0.3999
Early Rec Surveys	--	----	----	3	0.1563*	0.0063
NMFS LL NE	--	----	----	3	0.0161	0.2057

Table 2.34 Expected posterior values of parameters and time series for large coastals from the Bayesian production model analyses. Note: K (carrying capacity), N (abundance), MSC (maximum sustainable catch) and C 1975 - 1980 (landings in 1975 - 1980) are in thousands of sharks.

	Large Coastals Baseline Catch Series		Large Coastals Alternative Catch Series	
Parameter	Expected Value	CV	Expected Value	CV
K	9,535.00	0.17	11,754.00	0.16
r	0.07	0.50	0.05	0.50
C1975-80	284.00	0.39	327.00	0.42
MSC	149.00	0.38	143.00	0.40
N(98)	1,385.00	0.20	2,081.00	0.22
N(98)/K	0.15	0.24	0.18	0.23
N(75)	8,907.00	0.16	11,309.00	0.14
N(98)/N(75)	0.16	0.22	0.18	0.19

	Large Coastals Baseline Catch Series					Large Coastals Alternative Catch Series					
Year	N	N/K	N/N_{MSY}	F/F_{MSY}	F	Year	N	N/K	N/N_{MSY}	F/F_{MSY}	F
1974	8,927	0.95	1.90	1.12	0.03	1974	11,299	0.98	1.96	1.38	0.03
1975	8,671	0.92	1.84	1.15	0.03	1975	10,984	0.95	1.90	1.42	0.03
1976	8,430	0.90	1.79	1.19	0.03	1976	10,685	0.93	1.86	1.46	0.03
1977	8,202	0.87	1.74	1.23	0.04	1977	10,399	0.90	1.80	1.51	0.03
1978	7,985	0.85	1.70	1.26	0.04	1978	10,125	0.88	1.76	1.56	0.03
1979	7,777	0.83	1.65	1.30	0.04	1979	9,862	0.86	1.72	1.60	0.03
1980	7,577	0.81	1.61	1.34	0.04	1980	9,607	0.83	1.66	1.65	0.03
1981	7,387	0.79	1.57	1.35	0.04	1981	9,374	0.81	1.62	1.55	0.03
1982	7,130	0.76	1.52	2.14	0.06	1982	9,087	0.79	1.58	2.39	0.05
1983	6,640	0.71	1.41	4.08	0.12	1983	8,780	0.76	1.52	1.99	0.04
1984	6,250	0.66	1.33	1.59	0.05	1984	8,553	0.74	1.48	1.70	0.04
1985	6,047	0.64	1.28	2.28	0.07	1985	8,307	0.72	1.44	2.39	0.05
1986	5,733	0.61	1.22	3.14	0.09	1986	7,915	0.69	1.38	3.70	0.08
1987	5,371	0.57	1.14	3.29	0.09	1987	7,489	0.65	1.30	3.23	0.07
1988	4,913	0.52	1.04	5.04	0.15	1988	6,876	0.60	1.20	6.87	0.14
1989	4,370	0.46	0.93	5.51	0.16	1989	6,010	0.52	1.04	8.32	0.17
1990	3,906	0.41	0.83	4.91	0.14	1990	5,236	0.45	0.90	7.51	0.16
1991	3,520	0.37	0.75	5.17	0.15	1991	4,615	0.40	0.80	7.52	0.16
1992	3,126	0.33	0.66	6.16	0.18	1992	4,010	0.35	0.70	9.21	0.19
1993	2,761	0.29	0.59	5.72	0.17	1993	3,492	0.30	0.60	7.52	0.16
1994	2,446	0.26	0.52	6.14	0.18	1994	3,131	0.27	0.54	6.60	0.14
1995	2,125	0.23	0.45	7.32	0.21	1995	2,811	0.24	0.48	7.61	0.16
1996	1,820	0.19	0.39	7.36	0.21	1996	2,509	0.22	0.44	7.33	0.15
1997	1,585	0.17	0.34	6.34	0.18	1997	2,280	0.20	0.40	6.03	0.13
1998	1,387	0.15	0.29			1998	2,091	0.18	0.36		

Figure 2.3 Catch per unit effort series for large coastal sharks. Note change in scale. (1998 SEW Report)



Sandbar Sharks

In the analysis of the catch rate series for sandbar sharks, during the period 1993 to 1997, four of five catch rate indices exhibit positive slopes (one of which is statistically significant) and only one index exhibited a negative slope (which was not statistically significant). The largest annual rate of increase from these indices during this period was 37 percent, while the only index showing a decrease, decreased at one percent annually (Table 2.35).

For the sandbar shark baseline catch series (Table 2.36), results of the Bayesian model indicate that the stock size had continuously declined from about 3.3 million fish in 1974 to about 924,000 fish in 1998; maximum sustainable catch was 71,264 fish; the stock size in 1998 was only about 29 percent of carrying capacity or 58 percent of maximum sustainable yield levels; the landings in 1997 were about 1.3 times that which would produce maximum sustainable catch; and the 1997 fishing mortality rate was about 2.7 times higher than that which would produce maximum sustainable yield (Table 2.38). Projections indicated that the status quo policy would stabilize the stock level, but would not allow recovery (Nfin/K = 0.3 after ten years, and 0.31 after 20 and 30 years), with a probability of 41 percent that the stock size after ten, 20, and 30 years would be larger than the 1998 stock size. All the other options predicted faster stock recovery, but only the zero-landings policy allowed the stock to almost reach the maximum sustainable yield level after ten years. With the ten percent and 20 percent of 1995 landings options, maximum sustainable yield could be reached after 20 years, and after 30 years, maximum sustainable yield could be reached with the ten percent, 20 percent, and 30 percent of 1995 landings options (see Chapter 3).

For the sandbar shark alternative catch series (Table 2.37), projections were by far the most optimistic. Results indicate that the stock size had continuously declined from about three million fish in 1974 to about 941,000 fish in 1998; maximum sustainable catch was 109,043 fish; the stock size in 1998 was only about 35 percent of carrying capacity or 70 percent of maximum sustainable yield levels; the landings in 1997 were about 0.85 times lower than that which would produce maximum sustainable catch; and the 1997 fishing mortality rate was about 1.6 times higher than that which would produce maximum sustainable yield (Table 2.38). All landings policies allowed stock recovery to the level producing maximum sustainable yield after only ten years. The status quo policy had a 50 percent probability that stock size would be larger than the maximum sustainable yield level after ten years, and a 74 percent probability that the stock size would be larger than the 1998 stock size after ten years (see Chapter 3).

Table 2.35 Recent (1993 - 1997 and 1990 - 1997) trends in catch rates. Slopes and standard deviations (SD) of the slopes are expressed relative to the mean of the data points (n) in the slope calculation. Slopes that are significantly different from zero at a 0.1 probability level are marked with an *. (1998 SEW Report)

Index	1993 - 1997 Data			1990 - 1997 Data		
	n	slope	SD	n	slope	SD
Sandbar						
Virginia LL	4	0.1051	0.0696	7	0.1876*	0.0518
Pelagic Logs	4	0.1995	0.1584	4	0.1995	0.1584
Late Rec Surveys	5	0.1347	0.0771	5	0.1347	0.0771
NMFS LL SE	3	-0.0101	0.3082	3	-0.0101	0.3082
Shark Observer	4	0.3654*	0.0940	4	0.3654*	0.0940
Early Rec Surveys	--	----	----	3	-0.2917	0.2165
NMFS LL NE	--	----	----	3	0.1010	0.2348

Table 2.36 Estimates of the annual baseline landings of sandbar sharks based on area-gear definitions described in the NMFS 1996 SEW Report. (1998 SEW Report)

Year	Commercial Landings (lb)	Average Wt. (lb)	Landed Wt./ Ave. Wt. (lb)	Recreational Harvest (Number)	Rec+Com (Number)	Unreported (Number)	Total (Number)
1986	796,509	35.9	22,187	123,661	145,848	6,225	152,073
1987	2,285,644	35.9	63,667	32,551	96,218	17,575	113,793
1988	2,737,938	35.9	76,266	64,792	141,058	56,650	197,708
1989	4,215,657	35.9	117,428	27,415	144,843	48,150	192,993
1990	4,026,470	35.9	112,158	58,811	170,969	26,050	197,019
1991	3,292,594	35.9	91,716	36,794	128,510	5,650	134,160
1992	3,470,449	35.9	96,671	36,294	132,965		132,965
1993	2,483,235	35.9	69,171	26,607	95,778		95,778
1994	4,691,470	35.4	132,527	14,973	147,500		147,500
1995	3,012,065	36.4	82,749	24,869	107,618		107,618
1996	2,004,759	31.3	64,050	35,180	99,230		99,230
1997	982,100	30.7	31,990	40,929	72,919		72,919

Table 2.37 Estimates of the annual alternative landings of sandbar sharks based on area-gear definitions described in NMFS, 1996. Alternative sandbar catch series follow the same logic as the alternative large coastal catch series; differences from the baseline are in italics. (1998 SEW Report)

Year	Commercial Landings (lb)	Average Wt. (lb)	Landed Wt./ Ave. Wt. (lb)	Recreational Harvest (Number)	Rec+Com (Number)	Unreported (Number)	Total (Number)
1986	*1,593,018*	35.9	*44,374*	123,661	*168,035*	6,225	*174,280*
1987	*4,571,288*	35.9	*127,334*	32,551	*159,885*	17,575	*177,460*
1988	*5,475,876*	35.9	*152,531*	64,792	*217,323*	56,650	*273,973*
1989	*8,431,314*	35.9	*234,855*	27,415	*262,270*	48,150	*310,420*
1990	*8,052,940*	35.9	*224,316*	58,811	*283,127*	26,050	*309,177*
1991	*6,585,188*	35.9	*183,431*	36,794	*220,225*	5,650	*225,875*
1992	*6,940,898*	35.9	*193,340*	36,294	*229,634*		*229,634*
1993	*3,724,852*	35.9	*103,756*	26,607	*130,363*		*130,363*
1994	4,691,470	35.4	132,527	14,973	147,500		147,500
1995	3,012,065	36.4	82,749	24,869	107,618		107,618
1996	2,004,759	31.3	64,050	35,180	99,230		99,230
1997	982,100	30.7	31,990	40,929	72,919		72,919

Table 2.38 Expected posterior values of parameters and time series for sandbar from the Bayesian production model analyses. Note: K (carrying capacity), N (abundance), MSC (maximum sustainable catch) and C 1975 - 1980 (landings in 1975 - 1980) are in thousands of sharks. (1998 SEW Report)

	Sandbar Baseline Catch Series		**Sandbar Alternative Catch Series**	
Parameter	**Expected Value**	**CV**	**Expected Value**	**CV**
K	3,265.00	0.32	2,870.00	0.42
r	0.10	0.70	0.21	0.79
C1975-80	170.00	0.54	126.00	0.56
MSC	71.00	0.55	109.00	0.41
N(98)	924.00	0.45	941.00	0.47
N(98)/K	0.29	0.39	0.35	0.37
N(75)	3,313.00	0.33	2,945.00	0.45
N(98)/N(75)	0.29	0.41	0.35	0.41

	Sandbar Baseline Catch Series					**Sandbar Alternative Catch Series**					
Year	**N**	**N/K**	**N/N_{MSY}**	**F/F_{MSY}**	**F**	**Year**	**N**	**N/K**	**N/N_{MSY}**	**F/F_{MSY}**	**F**
1974	3,311	1.02	2.05	1.48	0.05	1974	2,960	1.03	2.06	0.74	0.04
1975	3,143	0.97	1.95	1.56	0.05	1975	2,830	0.99	1.97	0.77	0.04
1976	2,989	0.93	1.85	1.65	0.06	1976	2,720	0.95	1.90	0.81	0.05
1977	2,847	0.88	1.77	1.75	0.06	1977	2,630	0.92	1.84	0.84	0.05
1978	2,713	0.84	1.69	1.85	0.06	1978	2,540	0.89	1.79	0.87	0.05
1979	2,586	0.81	1.61	1.95	0.07	1979	2,470	0.87	1.74	0.90	0.05
1980	2,465	0.77	1.54	2.06	0.07	1980	2,400	0.85	1.70	0.93	0.05
1981	2,348	0.74	1.48	2.19	0.08	1981	2,330	0.83	1.66	0.96	0.05
1982	2,234	0.71	1.41	2.33	0.08	1982	2,270	0.81	1.62	0.99	0.06
1983	2,123	0.67	1.35	2.49	0.09	1983	2,210	0.79	1.59	1.02	0.06
1984	2,013	0.64	1.28	2.69	0.09	1984	2,150	0.78	1.56	1.06	0.06
1985	1,904	0.61	1.22	2.95	0.10	1985	2,100	0.76	1.53	1.09	0.06
1986	1,804	0.58	1.16	2.70	0.09	1986	2,030	0.74	1.47	1.59	0.09
1987	1,724	0.56	1.11	2.09	0.07	1987	1,940	0.70	1.40	1.81	0.10
1988	1,640	0.53	1.05	3.85	0.13	1988	1,800	0.65	1.29	3.04	0.18
1989	1,509	0.48	0.96	4.11	0.14	1989	1,600	0.57	1.14	3.94	0.23
1990	1,378	0.41	0.88	4.64	0.16	1990	1,390	0.49	0.98	4.63	0.27
1991	1,276	0.40	0.81	3.44	0.12	1991	1,230	0.43	0.86	3.92	0.23
1992	1,204	0.38	0.76	3.63	0.13	1992	1,100	0.38	0.77	4.56	0.26
1993	1,150	0.36	0.73	2.75	0.09	1993	1,020	0.36	0.71	2.82	0.16
1994	1,087	0.34	0.69	4.15	0.16	1994	977	0.34	0.68	3.31	0.19
1995	1,018	0.32	0.64	3.57	0.12	1995	943	0.33	0.67	2.48	0.14
1996	971	0.31	0.61	3.50	0.12	1996	933	0.34	0.67	2.27	0.13
1997	941	0.30	0.59	2.70	0.09	1997	940	0.34	0.69	1.62	0.09
1998	923	0.29	0.58			1998	962	0.36	0.72		

Blacktip Sharks

In the analysis of the catch rate series for blacktip sharks during the period 1993 to 1997, two of five catch rate indices exhibited positive slopes (one of which was statistically significant) and three of five indices exhibited a negative slope (one of which was statistically significant). The annual rate of change from these indices during this period ranged from 35 percent to 19 percent (Table 2.39).

For the blacktip shark baseline catch series (Table 2.40), results of the Bayesian model indicate that the stock size had continuously declined from about 5.1 million fish in 1974 to about 1.4 million fish in 1998; maximum sustainable catch was 136,727 fish; the stock size in 1998 was only about 25 percent of carrying capacity or 50 percent of maximum sustainable yield levels; the landings in 1997 were about 1.8 times that which would produce maximum sustainable catch; and the 1997 fishing mortality rate was about 3.5 times higher than that which would produce maximum sustainable yield (Table 2.42). Projections indicated that the status quo policy would not allow recovery of the blacktip shark stock (Nfin/K = 0.17, 0.14, and 0.13 after ten, 20, and 30 years respectively), with the probability that the stock size after ten, 20, and 30 years would be larger than the 1998 stock size being about 16 percent. The zero-landings policy indicated that the stock would reach the maximum sustainable yield level after between ten and 20 years. The only other policy that would allow for stock recovery after 20 years was the ten percent of 1995 quota policy (Nfin/K = 0.56). The maximum sustainable yield was predicted to be reached with zero landings, and the ten percent and 20 percent of 1995 quota policies after 30 years (see Chapter 3).

For the blacktip shark alternative catch series (Table 2.41), results indicate that the stock size had continuously declined from about 6.1 million fish in 1974 to about 1.4 million fish in 1998; maximum sustainable catch was 156,884 fish; the stock size in 1998 was only about 22 percent of carrying capacity or 44 percent of maximum sustainable yield levels; the landings in 1997 were about 1.6 times that which would produce maximum sustainable catch; and the 1997 fishing mortality rate was about 3.7 times higher than that which would produce maximum sustainable yield (Table 2.42). Predictions incorporating expanded catch followed the same general pattern as the baseline catch series scenario. Thus, projections indicated that the status quo policy would not allow recovery of the blacktip shark stock (Nfin/K = 0.16, 0.17, and 0.17 after ten, 20, and 30 years respectively), with the probability that the stock size after ten, 20, and 30 years were larger than the 1998 stock size being about 21 percent, 23 percent, 23 percent, respectively. The zero-landings policy indicated that the stock would reach the maximum sustainable yield level after between ten and 20 years. As with the baseline catch series scenario, the only other policy that would allow for stock recovery after 20 years was the ten percent of 1995 quota policy (Nfin/K = 0.53) and maximum sustainable yield was predicted to be reached with zero landings, and the ten percent and 20 percent of 1995 quota policies after 30 years (See Chapter 3).

Table 2.39 Recent (1993 - 1997 and 1990 - 1997) trends in catch rates. Slopes and standard deviations (SD) of the slopes are expressed relative to the mean of the data points (n) in the slope calculation. Slopes that are significantly different from zero at a 0.1 probability level are marked with an *.
(1998 SEW Report)

Index	1993 - 1997 Data			1990 - 1997 Data		
	n	slope	SD	n	slope	SD
Blacktip						
Pelagic Logs	5	-0.1920*	0.0445	6	-0.1385*	0.0387
Late Rec Surveys	5	-0.1277	0.0662	5	-0.1277	0.0662
Shark Observer	4	-0.0856	0.3799	4	-0.0856	0.3799
NMFS LL SE	3	0.0518	0.2945	3	0.0518	0.2945
Gulf Reef Logs	5	0.3462*	0.1252	5	0.3462*	0.1252
Early Rec Surveys	--	----	----	3	0.2285*	0.0272
NMFS LL NE	--	----	----	3	-0.0667	0.1734

Table 2.40 Estimates of the annual baseline landings of blacktip sharks based on area-gear definitions described in NMFS, 1996. (1998 SEW Report)

Year	Commercial Landings (lb)	Average Wt. (lb)	Landed Wt./ Ave. Wt. (lb)	Recreational Harvest (Number)	Rec+Com (Number)	Unreported (Number)	Mexico small fish (Number)	Total (Number)
1986	1,213,040	20.5	59,173	162,403	221,576	18,675	15,642	255,893
1987	1,463,544	20.5	71,392	129,552	200,944	52,725	22,346	276,015
1988	3,300,321	20.5	160,991	139,809	300,800	56,650	29,050	386,500
1989	3,832,421	20.5	186,947	111,363	298,310	48,150	35,754	382,214
1990	2,052,287	20.5	100,112	94,135	194,247	26,050	42,458	262,755
1991	2,744,292	20.5	133,868	150,794	284,662	5,650	49,161	339,473
1992	3,610,218	20.5	176,108	157,659	333,767		55,865	389,632
1993	3,086,965	20.5	150,584	109,054	259,638		62,569	322,207
1994	3,829,364	20.0	191,468	66,106	257,574		62,569	320,143
1995	2,915,797	20.9	139,512	67,046	206,558		62,569	269,127
1996	2,121,714	22.3	951,44	78,010	173,154		62,569	235,723
1997	1,709,694	22.6	75,650	68,284	143,934		62,569	206,503

Table 2.41 Estimates of the annual alternative landings of blacktip sharks based on area-gear definitions described in the 1996 NMFS SEW Report. Alternative blacktip catch series follow the same logic as the alternative large coastal catch series; differences from the baseline are in italics. (1998 SEW Report)

Year	**Commercial Landings (lb)**	**Average Wt. (lb)**	**Landed Wt./ Ave. Wt. (lb)**	**Recreational Harvest (Number)**	**Rec+Com (Number)**	**Unreported (Number)**	**Mexico small fish (Number)**	**Total (Number)**
1986	*2,426,080*	20.5	*118,345*	162,403	*280,748*	18,675	15,642	*315,065*
1987	*2,927,088*	20.5	*142,785*	129,552	*272,337*	52,725	22,346	*347,408*
1988	*6,600,642*	20.5	*321,982*	139,809	*461,792*	56,650	29,050	*547,492*
1989	*7,664,842*	20.5	*373,895*	111,363	*485,258*	48,150	35,754	*569,162*
1990	*4,104,574*	20.5	*200,223*	94,135	*294,358*	26,050	42,458	*362,866*
1991	*5,488,584*	20.5	*267,736*	150,794	*418,530*	5,650	49,161	*473,341*
1992	*7,220,436*	20.5	*352,216*	157,659	*509,875*		55,865	*565,740*
1993	*4,630,448*	20.5	*225,875*	109,054	*334,929*		62,569	*397,498*
1994	3,829,364	20.0	191,468	66,106	257,574		62,569	320,143
1995	2,915,797	20.9	139,512	67,046	206,558		62,569	269,127
1996	2,121,714	22.3	95,144	78,010	173,154		62,569	235,723
1997	1,709,694	22.6	75,650	68,284	143,934		62,569	206,503

Table 2.42 Expected posterior values of parameters and time series for blacktip from the Bayesian production model analyses. Note: K (carrying capacity), N (abundance), MSC (maximum sustainable catch) and C 1975 - 1985 (landings in 1975 - 1980) are in thousands of sharks. (1998 SEW Report)

	Blacktip Baseline Catch Series		Blacktip Alternative Catch Series	
Parameter	**Expected Value**	**CV**	**Expected Value**	**CV**
K	5,527.00	0.31	6,532.00	0.29
r	0.12	0.70	0.11	0.70
C1975-80	81.00	0.37	235.00	0.38
MSC	137.00	0.43	157.00	0.45
N(98)	1,383.00	0.57	1,441.00	0.56
N(98)/K	0.25	0.43	0.22	0.40
N(75)	5,179.00	0.31	6,097.00	0.28
N(98)/N(75)	0.27	0.47	0.25	0.45

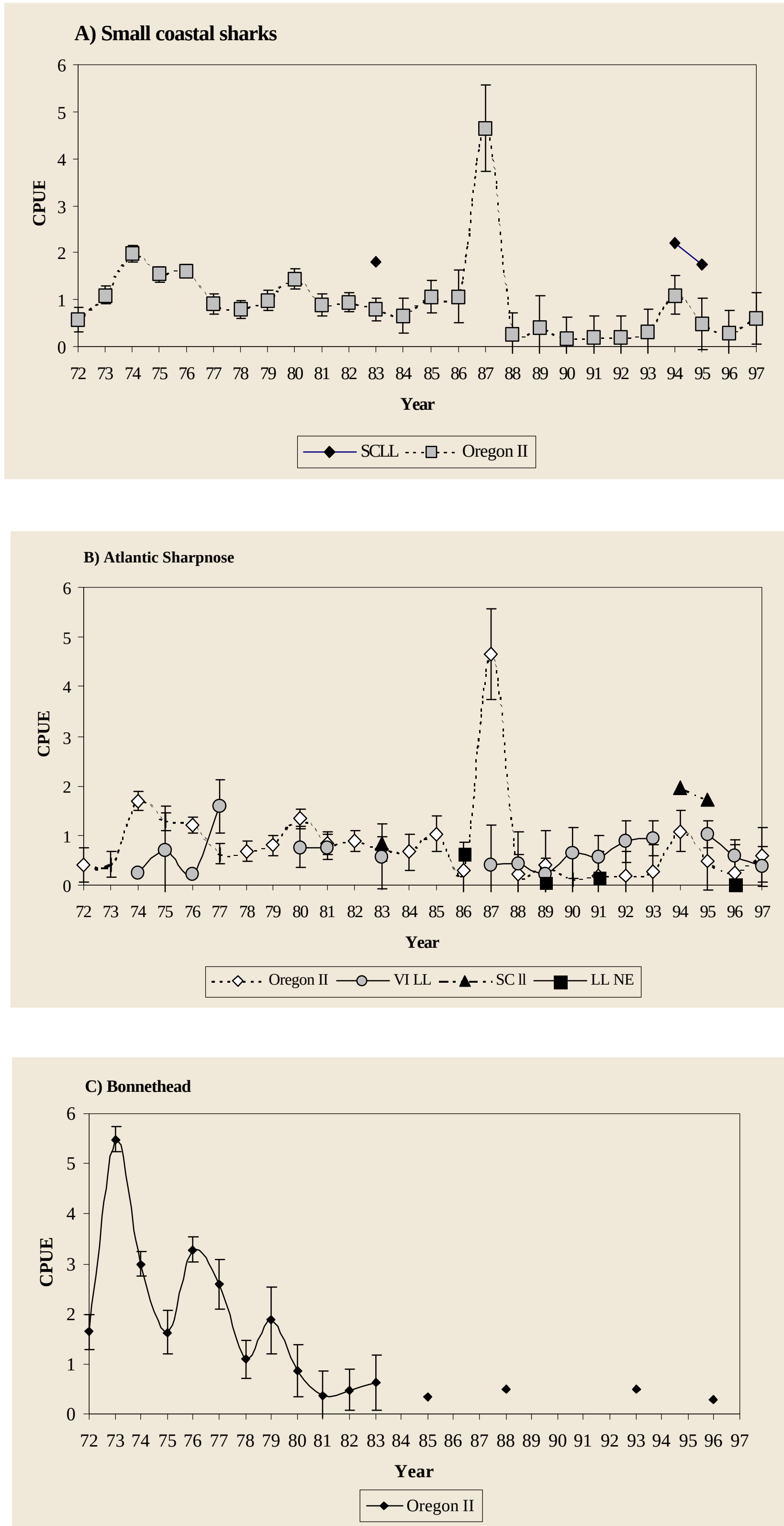
	Blacktip Baseline Catch Series					Blacktip Alternative Catch Series					
Year	**N**	**N/K**	**N/N_{MSY}**	**F/F_{MSY}**	**F**	**Year**	**N**	**N/K**	**N/N_{MSY}**	**F/F_{MSY}**	**F**
1974	5,192	0.96	1.91	0.93	0.05	1974	6,130	0.95	1.90	0.94	0.04
1975	4,996	0.92	1.84	0.97	0.05	1975	5,899	0.91	1.83	0.98	0.04
1976	4,820	0.89	1.77	1.01	0.05	1976	5,715	0.88	1.77	1.02	0.05
1977	4,659	0.86	1.71	1.05	0.05	1977	5,548	0.86	1.71	1.05	0.05
1978	4,510	0.83	1.66	1.09	0.05	1978	5,393	0.83	1.67	1.09	0.05
1979	4,371	0.80	1.60	1.12	0.05	1979	5,349	0.81	1.62	1.12	0.05
1980	4,240	0.78	1.56	1.16	0.06	1980	5,113	0.79	1.58	1.16	0.05
1981	4,116	0.76	1.51	1.27	0.06	1981	4,985	0.77	1.54	1.19	0.05
1982	3,997	0.74	1.47	1.24	0.06	1982	4,862	0.75	1.50	1.23	0.05
1983	3,884	0.71	1.43	1.28	0.06	1983	4,745	0.73	1.47	1.26	0.06
1984	3,774	0.70	1.39	1.32	0.06	1984	4,633	0.72	1.43	1.30	0.06
1985	3,667	0.68	1.35	1.37	0.07	1985	4,524	0.70	1.40	1.34	0.06
1986	3,545	0.66	1.31	1.61	0.08	1986	4,393	0.68	1.36	1.59	0.07
1987	3,399	0.63	1.26	1.81	0.09	1987	4,211	0.65	1.30	2.01	0.09
1988	3,191	0.59	1.18	2.70	0.13	1988	3,903	0.60	1.21	3.43	0.15
1989	2,936	0.54	1.08	2.92	0.14	1989	3,493	0.54	1.08	4.02	0.18
1990	2,747	0.50	1.01	2.15	0.11	1990	3,184	0.49	0.98	2.83	0.13
1991	2,577	0.47	0.95	2.97	0.14	1991	2,916	0.45	0.89	4.04	0.18
1992	2,342	0.43	0.86	3.78	0.18	1992	2,541	0.39	0.77	5.64	0.25
1993	2,115	0.39	0.77	3.51	0.17	1993	2,203	0.33	0.67	4.68	0.21
1994	1,916	0.35	0.70	3.91	0.19	1994	1,975	0.30	0.60	4.28	0.19
1995	1,738	0.32	0.63	3.70	0.18	1995	1,804	0.27	0.54	4.02	0.18
1996	1,597	0.29	0.58	3.61	0.18	1996	1,667	0.25	0.50	3.89	0.17
1997	1,481	0.27	0.54	3.52	0.17	1997	1,555	0.23	0.47	3.74	0.17
1998	1,373	0.25	0.50			1998	1,452	0.22	0.44		

2.4.1.2 Small Coastal Sharks

Concerns have been raised by members of the HMS Advisory Panel and the public that the assessment in the 1993 FMP was overly optimistic in its estimation of small coastal shark (SCS) intrinsic rates of increase and the subsequent levels of fishing mortality that this group can withstand, and that the small coastal shark quota which is based on this assessment is too high and should be reduced. NMFS has not conducted an evaluation of small coastal shark stock status since the 1993 evaluation, primarily due to the lack of sufficient catch per unit effort time series. Small coastal sharks are targeted in localized fisheries in the southern United States, caught incidentally in other commercial fisheries, and are commonly used for bait. Small coastal sharks are also commonly encountered in recreational fisheries in the southern United States, in coastal waters of the Atlantic Ocean and the Gulf of Mexico.

Species-specific fishery independent catch rate data only exist for Atlantic sharpnose and bonnethead sharks. Atlantic sharpnose shark catch rate data, which dominates the small coastal shark catch rate information, appear to be relatively stable, with a slightly increasing trend in the early 1990s and a slightly decreasing trend since 1995 (Figure 2.4). Bonnethead shark catch rate data (one extensive time series) exhibit strongly cyclical and decreasing trends from the early 1970s to the early 1980s, and a low but relatively stable trend since the early 1980s.

Figure 2.4 Catch per unit effort series for small coastal sharks. (SEW Report, NMFS, 1998)



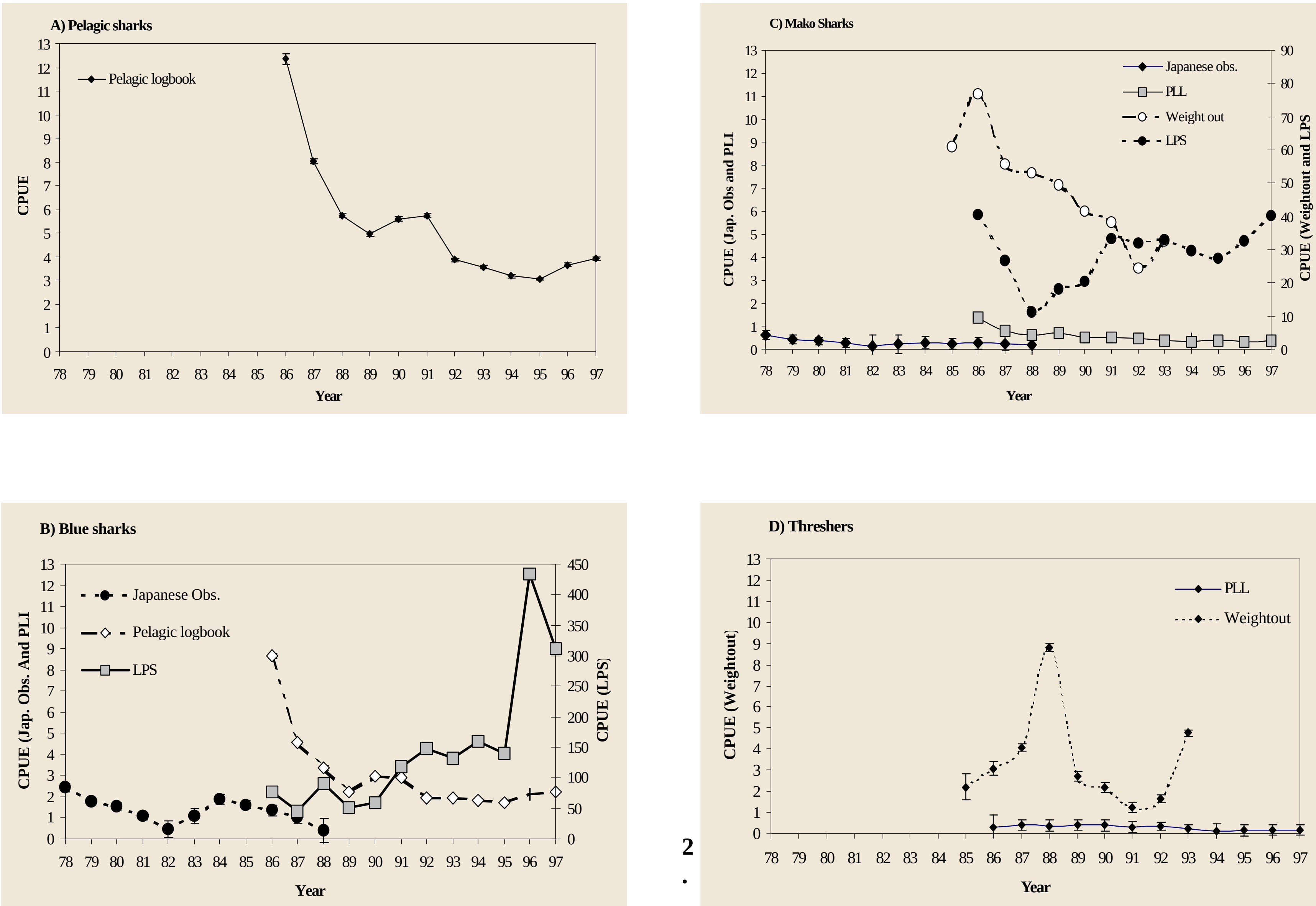
2.4.1.3 Pelagic Sharks

NMFS has not evaluated the stock status of pelagic sharks since 1993, primarily due to the lack of long-term and large scale (in terms of geographic coverage) time series. In fact, since no estimate of maximum sustainable yield could be calculated in the original Atlantic Shark FMP, the pelagic quota was based on the mean landings from 1986 to 1991. Several species within the pelagic shark management unit are trans-oceanic (e.g., blue, oceanic whitetip, and mako sharks) and are subject to exploitation by many nations. In order to conduct a comprehensive stock evaluation for pelagic sharks with all relevant catch, landings and catch rate time series, the cooperation of many nations is needed. However, a regional evaluation of porbeagle sharks (and potentially shortfin mako sharks) may provide scientifically valid results as the ranges and primary fisheries for these species are within the jurisdiction of only a few countries (e.g., Canada and the United States).

The available information on catch, landings, and catch rates, while informative of general trends, is insufficient to modify current estimates of maximum sustainable yield or quota levels for pelagic sharks. In general, catch rate data for the pelagic species combined indicate that the rapid decline seen in the late 1980s has apparently stabilized since 1992 (Figure 2.5). In general, blue, mako, and thresher sharks exhibit decreasing catch rates, although for both blue and thresher sharks the catch rates have increased slightly since 1995. However, catch rates for mako sharks from the LPS increased in 1996 and 1997, contrary to the Massachusetts Division of Marine Fisheries tournament catch per unit effort index data which indicate an 85-percent decline since 1994 (Philip Coates, Director, MA DMF, pers. comm.) and anecdotal evidence that the catches of shortfin mako sharks were greatly reduced in those years. Catch rates for thresher and oceanic whitetip sharks exhibit high variability. There is little evidence from the catch rate data that supports the need for more restrictive management measures at this time. However, members of the public have expressed the concern that the fully fished pelagic sharks may become overfished if the pelagic longline fishery, which encounters and lands pelagic sharks incidentally to tuna and swordfish fishing, begins to direct effort on pelagic sharks in response to declining tuna and swordfish quotas.

Additional concerns have been raised by members of the public regarding the susceptibility of porbeagle sharks to overexploitation given the potential for expansion in directed fishing effort on pelagic sharks. The porbeagle fishery in the northwest Atlantic is a classic example of a boom and bust commercial fishery that ceased to be commercially viable after only a few years. Currently, there is a small directed porbeagle fishery, predominantly in New England, as well as a moderate fishery for porbeagle sharks in Canada. Landings statistics are under review, but based on information reported by the Portland Fish Exchange, landings have been as high as 83 mt dw in recent years. Based on historical catch rates, NMFS has concluded that porbeagle sharks should be managed separately from the combined pelagic shark unit and carefully monitored to ensure that fishing mortality rates are sustainable.

Figure 2.5 Catch per unit effort series for Pelagic sharks. Note change in scale. (SEW Report, NMFS, 1998).



2.

4.2 International Aspects of the Atlantic Shark Fisheries

There is no foreign fishing for sharks allowed in U.S. waters. Pelagic sharks are caught in the ICCAT Convention area, often as bycatch in the tuna and swordfish fisheries, but their harvest is not currently managed by ICCAT. Member nations have not yet determined whether shark management is within the purview of the Commission. However, ICCAT's research activities have included the collection of bycatch statistics in swordfish and tuna fisheries, including shark bycatch, since 1994. ICCAT's Standing Committee on Research and Statistics has since established a Sub-Committee on Bycatch and a Shark Working Group to improve the quality of statistical information, collect additional species-specific data, and incorporate information on sharks into ICCAT's statistical databases. The Sub-Committee on Bycatch will meet in May 1999 to discuss catch rate indices for sharks.

The Food and Agriculture Organization of the United Nations (FAO) also collects limited data on shark landings and trade, not including recreational or artisanal harvests of sharks. Few countries submit species-specific data and some harvesting countries submit no information at all. Bycatch of sharks and finning are widespread practices that are not well-documented. As a result, fishing mortality is seriously under-reported and it is difficult to determine the potential effects of international fishing effort on the stocks. The international fishery for sharks is growing rapidly, but most of the expansion in recent years has taken place in the Pacific Ocean. Landings of Atlantic sharks reported to FAO have remained fairly constant since 1990. The 1995 landings that were reported to FAO in the Atlantic Ocean (excluding the Mediterranean) totaled 242,413 mt (FAO, 1997). The country with the highest reported landings of elasmobranchs (including sharks, rays, and skates) for the Atlantic, Pacific, and Indian Oceans combined is Indonesia, followed by India, Chinese-Taipei, United States, Mexico, and Japan (FAO, 1997).

Japan is a major market for sharks, although landings have declined in recent years and imports are increasing to meet Japanese demand for shark products. Japan has increased shark imports from $600,000 worth of sharks in 1976 to $18 million in 1997 (NOAA, 1998). In 1996, Japan reported landing only 1,270 mt of sharks in the Atlantic Ocean, down from a recent high of 4,710 mt in 1994 (FAO, 1997). Between 1991 and 1996, an average of 71 percent of Japanese shark landings was made by pelagic longline vessels targeting tuna, and the rest by other longline fisheries, trawl, gillnet and other methods (NOAA, 1998).

Mexican shark landings in the Gulf of Mexico and Caribbean are primarily part of multispecies artisanal fisheries that fluctuate according to seasonal abundance (Castillo and Marquez, 1996; Castillo *et al.*, 1998). This fishery supplies low-cost fresh and dried-salted meat for the domestic market. Mexico's shark landings in the Gulf of Mexico are dominated by Atlantic sharpnose, bonnethead, and blacktip sharks (Bonfil, 1997). Blacktip sharks are known to migrate from the western U.S. Gulf into the Mexican Gulf. In 1993, Mexico issued a moratorium on new commercial permits in the shark fishery to limit the number of participating vessels. Through the Instituto Nacional de Pesca, Mexico is collecting data to determine the level of shark bycatch in other fisheries, particularly tuna and swordfish fisheries. The 1998 SEW attempted to incorporate Mexican landings and recommended collection of more information about the species and size composition of Mexican catches and landings as well as the rates of movement of large coastal sharks, particularly blacktip and sandbar sharks, in Mexican and U.S. waters.

Canadian landings of Atlantic sharks consist primarily of porbeagle, shortfin mako, and blue sharks and a Shark Management Plan for these species was established in 1995 (Anonymous, 1995; Hurley, 1998). A seasonal directed longline fishery exists for porbeagle sharks with approximately three freezer longline vessels and 20 inshore vessels fishing between March and November. A directed fishery for blue sharks is developing with approximately 20 inshore pelagic longline and handline vessels fishing primarily on the Scotian Shelf between July and October. Shortfin mako sharks are taken primarily as bycatch in the swordfish longline fishery. Landings increased to 1922 mt by 1994, comprised of 1545 mt of porbeagle, 157 mt of shortfin mako, 113 mt of blue, and 107 mt of unspecified sharks (Hurley, 1998). In 1995, Canada established precautionary catch limits for porbeagle (1500 mt), blue shark (250 mt), and shortfin mako sharks (250 mt) in the directed shark fishery, established landings threshold criteria for a limited entry program, specified that licenses are exploratory, prohibited finning, restricted fishing gears and areas, established seasons, and restricted the recreational fishery to hook and line release only (Anonymous, 1995; Hurley, 1998). The Canadian plan is designed to: 1) provide for a reasonable scientific basis for management, 2) control the commercial and recreational shark fisheries so that they are economically viable in the long term, and 3) foster partnerships with the industry on the scientific study and management of the resource (Anonymous, 1995).

2.4.3 Domestic Aspects of the Atlantic Shark Fisheries

Cooperation with states in developing coordinated conservation measures is important to successful domestic shark management. In 1996 and 1997, NMFS sent letters to all Atlantic and Gulf of Mexico state fishery directors strongly urging states to: 1) implement shark fishery regulations at least as restrictive as Federal regulations; 2) close state fisheries in conjunction with Federal shark fishery closures; 3) prohibit fishing for sharks in important nursery areas; 4) apply recreational retention limits to recreational fishermen regardless of where sharks are caught; 5) prohibit the sale of recreationally-caught sharks and shark products; and 6) prohibit finning and adopt other measures that govern how and when fins may be landed.

In July 1997, in an effort to protect juvenile sandbar and dusky sharks, the State of North Carolina prohibited possession of all sharks taken by commercial gear in state waters, excluding Atlantic sharpnose sharks and pelagic sharks. In January 1998, the Mid-Atlantic Fishery Management Council passed a motion encouraging all the states between Maine and Texas to close their state waters to all directed fishing for large coastal sharks in order to protect pupping and nursery areas. The New England Fishery Management Council supported the Mid-Atlantic Council's recommendation and requested that NMFS do everything possible to facilitate the closing of large coastal shark pupping and nursery areas in state and Federal waters to directed fishing for large coastal sharks. The National Audubon Society's Living Oceans Program released a publication in 1998, "Sharks on the Line: A State-by-State Analysis of Sharks and Their Fisheries," which concludes that current Federal regulations alone are inadequate to ensure the recovery of Atlantic and Gulf shark populations and urges states to go beyond Federal regulations and establish or further restrict current shark fishing regulations. Several Atlantic and Gulf states, notably Delaware, Virginia, New Jersey, Georgia, and Louisiana have recently implemented or are in the process of implementing shark regulations. At the February 1999 meeting of the HMS AP, the regulations proposed for this FMP were discussed specifically with regard to impacts on the states. In response to NMFS' letter to the states requesting Coastal Zone Management Act (CZMA) certification, only Georgia objected to the FMP for lack of consistency with Georgia state regulations due to the continued allowance of the shark drift gillnet fishery off their waters.

At the 1998 annual meeting, the Atlantic States Marine Fisheries Commission Policy Board passed two motions regarding shark management. The first motion called for "the Policy Board to consider the options of the Commission relative to enhancing the management of sharks in state water." The second stated "... the Policy Board recommends that the member states adopt complementary regulations consistent with all federal shark measures including but not limited to minimum sizes, fishery closures once federal quotas are reached, and prohibition of take of exceptionally vulnerable species and life stages; and consider development of an Interstate Shark FMP." The Atlantic States Marine Fisheries Commission conducted a Technical Shark Workshop in April 1999, to collect state by state information on shark fisheries, review materials from the Federal Shark FMP, and develop options for possible shark management. NMFS will continue to work with Atlantic and Gulf of Mexico states and Regional Fishery Management Councils and Commissions to develop consistent state and Federal shark regulations.

Commercial Fishery

In the early years of the 20th century, a Pacific shark fishery supplied limited demands for fresh shark fillets and fish meal as well as a more substantial market for dried fins of soupfin sharks. In 1937, the price of soupfin shark liver skyrocketed when it was discovered to be the richest source of vitamin A available in commercial quantities. A shark fishery along the Atlantic coast developed in response to this demand. Sixteen vessels began targeting sharks off the southeastern coast of the United States, including a shark longline fishery in Salerno, Florida that operated nearly continuously from 1936 to 1950 (Springer, 1952). At this time, all shark fishing was done with chain sets, except for one vessel known to set nearshore gillnets for nurse sharks. The weight of the chain line normally confined fishing to depths less than 46 meters. When currents were not strong, however, sets were made at depths to 91 meters. In the last years of this fishery, the catch per unit effort increased due to further expansion of the fishery and a bonus arrangement that encouraged cooperation among the fishermen. By 1950, landings had decreased to a pre-1937 level of 322 mt due to a combination of overfishing, imports, and the availability of synthetic vitamin A (Springer, 1950; Wagner, 1966).

A small fishery for porbeagle existed in the early 1960s off the U.S. Atlantic coast involving Norwegian fishermen. Between the World Wars, Norwegians and Danes had pioneered fishing for porbeagles in the North Sea and in the region of the Shetland, Orkney, and the Faroe islands. In the late 1940s, these fishermen caught from 1,360 to 2,720 mt yearly, with lesser amounts in the early 1950s (Rae, 1962). The subsequent scarcity of porbeagles in their fishing area forced the Norwegians to explore other grounds, and around 1960, they began fishing the Newfoundland Banks and the waters east of New York. Between 1961 and 1964, their catch increased from 1,800 to 9,300 mt, then declined to 200 mt (Casey *et al*., 1978).

Shark fisheries developed rapidly in the late 1970s due to increased demand for their meat, fins, and cartilage. At the time, sharks were perceived to be underutilized as a fishery resource. The high commercial value of shark fins led to the controversial practice of finning, or removing the valuable fins from sharks and discarding the carcass. Growing demand for shark products encouraged expansion of the commercial fishery throughout the late 1970s and the 1980s. Tuna and swordfish vessels began to retain a greater proportion of their shark incidental catch, and some directed fishery effort expanded as well. As catches accelerated through the 1980s, shark stocks suffered a precipitous decline. Peak commercial landings of large coastal and pelagic sharks were reported in 1989.

While organized intensive shark fisheries have fluctuated, more localized shark fisheries have existed for many years. Directed fisheries for Atlantic sharks are conducted by vessels using bottom longline, gillnet, and rod and reel gear. Directed commercial longline fishing vessels currently catch primarily sandbar, dusky, and blacktip sharks. Sandbar and blacktip sharks make up approximately 60 to 75 percent of the commercial catch and approximately 75 to 95 percent of the commercial landings (Gulf and South Atlantic Fisheries Development Foundation, Inc., 1996). The remainder of the catch is comprised mostly of bull, bignose, tiger, sand tiger, lemon, spinner, scalloped hammerhead and great hammerhead sharks, with catch composition varying by region. These species are less marketable and are often released so they are reflected in the overall catch but not the landings.

In 1993, NMFS completed an FMP for Atlantic sharks that implemented the following measures: 1) a fishery management unit containing 39 frequently-caught species of Atlantic sharks, separated into three groups for assessment and regulatory purposes (large coastal, small coastal, and pelagic), 2) a fishing year of January 1 through December 31 to which a calendar year quota is allocated (for large coastals and pelagics), and further divided into two equal six-month period sub-quotas (January to June; July to December), 3) retention limits for the recreational fishery, 4) a commercial permit requirement for sale of catch subject to earned income criteria, and 5) prohibition of finning of Atlantic sharks. Unlike other HMS, sharks are not subject to ICCAT's management authority, so quota levels are established by NMFS.

A number of difficulties arose in the initial year of implementation of the Atlantic Shark FMP. Derby-style fishing, coupled with what some participants observed to be an unusual availability of sharks, led to an intense fishing season for large coastal sharks, with the fishery closing within one month. Oversupply of shark carcasses led to reports of record low prices. The short fishing season also complicated the task of monitoring the large coastal shark quota and of closing the season with the required advance notice. Because the closure was significantly earlier than expected and a number of commercial fishermen and dealers indicated that they were adversely affected, NMFS established a 4,000-pound commercial retention limit on large coastal sharks for commercial fishing vessels, with no limits on landings from the two other species groups. These commercial retention limits were intended to extend the fishing season as long as possible, in order to reduce the waste, economic disruption, and safety problems associated with a derby fishery. Other problems in this fishery included an excessive harvesting capacity relative to the allowable catches and market gluts.

The 1993 FMP concluded that large coastal sharks were overfished, that pelagic sharks and small coastal sharks were fully fished, and that stock recovery to levels of the 1970s would be slow due to the relatively low intrinsic rates of increase exhibited by these species. The 1994 SEW concluded that the scheduled quota increase for 1995 should be delayed indefinitely. The 1996 SEW reiterated that the large coastal stock continued to be overfished. While the rapid rate of decline that characterized the stocks in the 1980s had slowed significantly, by 1996, reductions in fishing mortality of 50 percent or more would be required to ensure a reasonable probability of stock increases over the next two years.

In 1997, NMFS reduced the overall commercial quota of 2,570 mt dw by 50 percent to 1,285 mt dw for the large coastal species group, established a 1,760 mt dw quota for the small coastal species group, and maintained the commercial quota for the pelagic species group at 580 mt dw. The retention limits for the recreational fishery were reduced from four per vessel per trip for the large coastal and pelagic species groups combined and five per person per day for the small coastal species group to two sharks per vessel per day for all species combined, except for Atlantic sharpnose sharks for which NMFS established an allowance two fish per person per trip. In addition, landing or sale of whale, basking, sand tiger, bigeye sand tiger, and white sharks was prohibited. These measures were designed to prevent development of directed fisheries for species particularly vulnerable to over-exploitation and increase the accuracy of species-specific identification.

Commercial landings of large coastal sharks declined in 1997 as a result of the new management measures (Table 2.43). Commercial pelagic shark landings have not reached the commercial quota of 580 mt dw since the implementation of the original shark FMP, although they did increase by 20 percent to 433 mt dw in 1997, the year of the 50-percent cut in the large coastal shark quota, possibly indicating some substitution (Table 2.44). Thus, only those pelagic shark species that lack commercial value are discarded; there should be no regulatory discards. Mako, porbeagle, and thresher sharks comprise 98 percent of the landings (Table 2.45). Data submitted from the Portland Fish Exchange, Inc. (Portland, ME), indicate that landings of porbeagle sharks ranged from 10.3 mt dw in 1998 to 83.4 mt dw in 1994, with an average of 36.6 mt dw (Barbara Stevenson, pers. comm.).

Estimates of the pelagic sharks discarded dead each year in the tuna and swordfish longline fisheries range from approximately 300 to 1,200 mt ww from 1987 to 1995, of which approximately 60 to 95 percent by weight are blue sharks (about 9,000 to 30,000 fish) (Table 2.46; Cramer, 1996). Blue sharks are frequently discarded because their unpalatable meat has minimal commercial value. Estimates of pelagic sharks discarded in the pelagic longline fisheries in 1996 and 1997 are 839 and 253 mt ww, respectively, of which approximately 73 percent are blue sharks (about 19,000 and 8,000 fish) (Cramer *et al*., 1997; Cramer and Adams, 1998; Table 2.46). Estimates of pelagic sharks discarded dead in other fisheries in 1996 and 1997 are 110 and 56 mt ww, respectively, of which 93 and 58 percent are blue sharks (about 3000 and 1400 fish) (see Cramer *et al*., 1997; Cramer and Adams, 1998).

Thus, in 1996, the total estimate (pelagic longline and other) of dead discards is 82 percent of the commercial pelagic shark quota, with blue shark dead discards comprising 62 percent of the quota. In contrast, the total estimate of dead discards in 1997 is 27 percent of the commercial pelagic shark quota, with blue shark dead discards comprising 19 percent of the quota. When blue sharks are not included, the estimate of dead discards in 1996 is about 119 mt dw, or 20 percent of the pelagic shark quota, and in 1997, the estimate of dead discards is about 46 mt dw, or eight percent of the pelagic shark quota. Estimates of blue sharks discarded alive range by area, quarter, and year from approximately 30 to 100 percent during the period 1992 to1995 (Cramer, 1996). Catches of blue sharks (in numbers) in the Grand Banks and Northeast Coastal areas often are near or exceed the catch of the targeted swordfish and tuna (Cramer, 1996).

Historically, small coastal sharks were incidental catch in commercial fisheries, and commonly used for bait. Observer data indicate that small coastal shark landings represent (by number) two percent, 19 percent, and 72 percent of the total observed mortality of the small coastal shark catches in the directed shark longline fishery for the North Carolina, west Florida, and south Atlantic Bight regions, respectively (see Table 6, Branstetter and Burgess, 1997). These data indicate that approximately 98 percent, 81 percent, and 28 percent, respectively, of the small coastal shark catch in those regions was not landed but was used for bait. Note that observer data for the North Carolina and west Florida areas suggest that unreported mortality of small coastal sharks is high; however, the volume of small coastal shark catches in those areas is minor. Nevertheless, small coastal shark landings statistics may considerably underestimate mortality in this fishery. Commercial landings of small coastal sharks have increased from nine mt dw in 1994 to 326 mt dw in 1997 (Table 2.47), with Atlantic sharpnose, blacknose, and finetooth sharks comprising 90 percent of the landings.

Given the short directed fishing season for sharks, fishermen have had to diversify in order to maintain their financial viability, either into other fisheries or other occupations. Many participants in the commercial shark fishery are engaged in the longline fishery for swordfish and tuna, the gillnet fisheries, the hook and line fisheries, or the snapper-grouper or reef fish fisheries. The NMFS permit database indicates that more than 97 percent of permitted shark fishermen hold other fishing permits from the Southeast Regional Permit Office (1998). As part of this FMP, NMFS is implementing a limited access system for the commercial fishery that is based on current and historical participation in the fishery. The purpose of limited access is to reduce latent effort in the shark fishery and prevent further overcapitalization. The limited access system is fully described in Chapter 4.

Recreational Fishery

Recreational fishing for Atlantic sharks occurs in federal and state waters from New England to the Gulf of Mexico and Caribbean Sea. U.S. recreational shark harvests have declined somewhat from the peak recorded catches in 1983. In 1990, the International Game Fishing Association named the following Atlantic sharks as those typically targeted by recreational fishermen: blue, shortfin mako, porbeagle, and thresher sharks (in the pelagic management unit); and the tiger and hammerhead sharks (in the large coastal management unit) (Rose, 1996).

For pelagic species, some of which are considered prized gamefish (e.g., makos), recreational harvests have fluctuated from a peak of approximately 93,000 fish in 1985 to a low of about 6,000 fish in 1994. The apparent decline of shortfin mako sharks is of substantial concern to the recreational fishing community. Recreational landings of small coastal sharks have fluctuated around 50,000 to 150,000 fish per year since the mid 1980s, with Atlantic sharpnose comprising about 65 percent of the catches (Tables 2.47 and 2.48)

The 1993 FMP for Atlantic sharks established a recreational retention limit of five small coastal sharks per person per day. In 1997, NMFS combined the recreational retention limit into an all-shark limit of two fish per vessel per trip with an allowance for two Atlantic sharpnose sharks per person per trip. This measure was designed to address concerns that juvenile large coastal sharks were being misidentified as small coastal sharks, while the additional allowance for Atlantic sharpnose sharks was intended to allow anglers on charter/partyboats the opportunity to land a shark. In response to the overfished designation of large coastals, NMFS reduced the recreational retention limit by 50 percent in 1997. Sharks that are not retained by the angler must be released in a manner to ensure the maximum possibility of survival. Fishing for white sharks is catch and release only.

A future NMFS employee proudly displays his first catch. Photo credit: George Darcy, NMFS

Table 2.43 Large coastal sharks commercial and recreational landings. Numbers and weights are converted to weights and numbers using an average size. (SB-III-5; SB-III-6; Scott *et al.*, 1998)

Year	Commercial Landings (lb dw)	Recreational Harvest (lb dw)	Total Landings (lb dw)	Commercial Landings (Number)	Recreational Harvest (Number)	Total Landings (Number)
1986	2,533,492	8,916,855	11,450,347	53,996	426,119	480,115
1987	4,817,293	8,583,245	13,400,538	104,656	314,379	419,035
1988	7,747,849	7,108,406	14,856,255	274,649	300,592	575,241
1989	10,141,149	6,144,728	16,285,877	351,026	221,052	572,078
1990	7,691,300	2,659,046	10,350,346	267,523	213,216	480,739
1991	8,139,134	2,612,873	10,752,007	200,175	293,259	493,434
1992	8,609,981	3,050,456	11,660,437	143,501	304,895	448,396
1993	6,775,795	2,224,289	9,000,084	89,629	248,988	338,617
1994	8,438,581	1,869,291	10,307,872	190,136	160,869	351,005
1995	6,870,848	2,342,353	9,213,201	160,394	183,434	343,828
1996	5,262,314	2,356,732	7,619,046	170,504	184,560	355,064
1997*	3,127,223	2,068,231	5,195,454	103,406	161,967	265,373

*1997 data are preliminary

Table 2.44 Pelagic sharks commercial and recreational landings. Numbers and weights are converted to weights and numbers using an average size. (Scott *et al*., 1996; Poffenberger, 1996; Scott *et al*., 1998)

Year	Commercial Landings (lb dw)	Recreational Harvest (lb dw)	Total Landings (lb dw)	Commercial Landings (Number)	Recreational Harvest (Number)	Total Landings (Number)
1986	269,912	7,542,466	7,812,378	4,264	42,092	46,356
1987	603,516	3,795,202	4,398,718	8,722	37,259	45,981
1988	1,135,734	3,886,981	5,022,715	15,580	33,418	48,998
1989	2,026,772	3,024,180	5,050,952	31,121	22,609	53,730
1990	1,595,497	1,148,853	2,744,350	23,090	15,359	38,449
1991	705,529	715,223	1,420,752	9,295	11,553	20,848
1992	1,370,698	1,444,062	2,814,760	18,132	16,418	34,550
1993	1,207,666	2,782,806	3,990,472	14,819	31,271	46,090
1994	986,808	665,920	1,652,728	18,953	6,151	25,104
1995	834,723	3,046,364	3,881,087	11,521	32,891	44,412
1996	695,531	1,930,016	2,625,547	9,594*	20,838	191,342
1997*	955,313	776,433	1,731,746	13,177*	8,383	111,789

*1997 data are preliminary. 1996 and 1997 commercial landings by number converted from weight using the 1995 average size.

Table 2.45 Estimated landings estimates of pelagic sharks in commercial and recreational fisheries for 1996 and 1997. Note: commercial landings are in pounds dressed weight and recreational harvest are in numbers of fish. Note: landings of fins are included in the commercial estimate. (Scott *et al*., 1998)

Species	Commercial Landings		Recreational Harvest	
	1996	1997	1996	1997
Bigeye thresher	5,295	5,308		
Blue	10,228	967	10,461	4,265
Cow		81	443	54
Longfin mako	5,923	2,112		
Mako genus			7	10
Oceanic whitetip	217,254	3,656		
Porbeagle	46,424	3,690		
Shortfin mako	158,422	261,825	9,062	2,618
Thresher	237,507	109,030	865	1,436
Unclassified	14,478	568,644		
TOTAL	**695,531**	**955,313**	**20,838**	**8,383**

*1997 data are preliminary

Table 2.46 Blue shark dead discards as a percentage of all pelagic shark dead discards by Pelagic Longline Vessels for 1987 - 1997. 1996 and 1997 includes other gear. (Cramer, 1996; Cramer *et al*., 1997; Cramer and Adams, 1998)

Year	Pelagic Sharks			Blue Sharks			Percent of Pelagic Sharks MT (dw)
	Number	MT (ww)	MT (dw)	Number	MT (ww)	MT (dw)	
1987	13,092.00	560.64	280.32	12,506.00	526.20	263.10	93.86
1988	13,655.00	468.73	234.37	12,934.00	421.16	210.58	89.85
1989	13,480.00	538.21	269.11	12,525.00	480.01	240.00	89.19
1990	13,955.00	795.97	397.99	13,141.00	741.34	370.67	93.14
1991	17,232.00	813.21	406.61	16,562.00	772.32	386.16	94.97
1992	8,940.00	298.30	149.15	7,043.00	184.39	92.20	61.81
1993	30,544.00	1,191.53	595.77	29,329.00	1,136.33	568.17	95.37
1994	13,411.00	637.70	318.85	11,986.00	572.24	286.12	89.73
1995	8,738.00	307.75	153.88	7,325.00	242.39	121.20	78.76
1996*	22,153.00	949.22	474.61	18,996.00	710.69	355.34	74.87
1997*	9,284.00	310.55	155.02	7,777.00	219.28	109.64	70.72

Table 2.47 Small coastal sharks commercial and recreational landings. Numbers and weights are converted to weights and numbers using an average size. (Scott *et al*., 1996; Poffenberger, 1996; Scott *et al*., 1998)

Year	Commercial Landings (lb dw)	Recreational Harvest (lb dw)	Total Landings (lb dw)	Commercial Landings (Number)	Recreational Harvest (Number)	Total Landings (Number)
1986	NA	256,614	256,614	NA	34,923	34,923
1987	NA	462,257	462,257	NA	48,751	48,751
1988	NA	804,639	804,639	NA	82,375	82,375
1989	NA	596,546	596,546	NA	62,335	62,335
1990	NA	603,306	603,306	NA	47,281	47,281
1991	1,164	1,151,499	1,152,663	NA	137,018	137,018
1992	NA	674,675	674,675	NA	116,163	116,163
1993	7,766	538,329	546,095	NA	78,680	78,680
1994	20,510	733,289	753,799	3,717	103,193	106,910
1995	40,010	953,970	993,980	4,125	135,085	139,210
1996	460,667	795,993	1,256,660	143,958	112,715	256,673
1997*	719,341	685,162	1,404,503	224,794	97,021	321,815

Table 2.48 Estimated landings estimates of small coastal sharks in commercial and recreational fisheries for 1996 and 1997. Note: commercial landings are in pounds dressed weight and recreational harvest is in numbers of fish. Note: landings of fins are included in the commercial estimate. (Scott *et al*., 1998)

Species	Commercial Landings		Recreational Harvest	
	1996	1997	1996	1997
Atlantic angel			3,814	
Atlantic sharpnose	165,171	256,632	73,018	65,530
Blacknose	140,790	202,781	11,737	10,761
Bonnethead	60,694	75,787	21,996	15,730
Caribbean sharpnose	876			
Finetooth	92,980	184,141	1,602	5,000
Smalltail			548	
Unclassified	4			
TOTAL	**460,515**	**719,341**	**112,715**	**97,021**

*1997 data are preliminary

2.4.4 Social and Economic Aspects of the Domestic Atlantic Shark Fisheries

Commercial Fishing

There is significant demand for shark meat in markets throughout the United States, Asia, and Europe. During 1995, shark imports on the international market (from all oceans) totaled 53,000 mt with a value of $169 million (NOAA, 1998). Frozen shark products accounted for 67 percent in volume and fresh shark products accounted for 30 percent in volume, while dried shark fins accounted for three percent in volume (NOAA, 1998). Wholesale prices for sharks vary widely, depending upon quality, product form, market factors, and species.

In general, the most valuable species include shortfin mako, thresher, porbeagle, and requiem sharks, dogfish, and smoothhounds (Weber and Fordham, 1997). The highest-quality meat is sold as sashimi or steaks in fresh seafood markets. Weber and Fordham (1997) reported regional preferences for shark fins. In Hong Kong, processors seek the fins of hammerhead, tiger, oceanic whitetip, blacktip, dusky and blue sharks, while the fins of thresher, nurse sharks, and ray and skate wings have minimal value. In Taiwan, fin traders prefer the hammerhead, dusky, and blacktip reef sharks, and place a lower value on the thresher and blue sharks. In the United States domestic market, buyers generally prefer hammerhead and sandbar shark fins, followed by the dusky, tiger, blacktip, bull, and silky sharks (Weber and Fordham, 1997).

In addition to markets for shark meat and fins, there is extensive world trade in other shark products including leather, cartilage, liver oil, and jaws. While smaller sharks are preferred for human consumption, due to the greater ease of storage and lower concentrations of urea and mercury in the flesh, larger sharks are more often used for dried fins and leather products. It is difficult to process sharks for both meat and skins, primarily because skins must be processed immediately to preserve their quality (Rose, 1996). Shark cartilage is processed into tablets for cancer treatment. Liver oil is also used in pharmaceuticals, lubricants, and cosmetics.

During the winter, the directed shark fishery is concentrated in the southeastern United States, particularly in Florida, since large coastal sharks tend to migrate south in winter. During the summer, large coastal sharks are more widely dispersed, allowing vessels in the mid-Atlantic and Northeast to participate in the fishery. In the Northeast region, commercial pelagic longline fisheries for swordfish and tuna encounter some sharks as the secondary target species. Many sharks are discarded except for species like mako, thresher, and porbeagle sharks whose fins and meat command higher prices. These sharks are a marketable component of the traditional catch of the pelagic longline fishery.

Nearly all Atlantic shark fishermen operate in the multispecies longline fishery where gear requirements are substantially similar. McHugh and Murray (1997) compared the proportion of catch per trip by value for a sample of directed shark fishing vessels in surveys conducted over two periods, one before and one after implementation of the Shark FMP in April 1993. Survey data reveal that the share of sharks, in total trip catch value, declined from 90.8 percent to 62.1 percent. In contrast, the share of grouper, in total value, increased from 6.9 percent to 34 percent. The 1993 finning prohibition and quota cuts, along with the 1994 commercial retention limit, likely played a role in this changing composition, although a more important factor may have been the increase in grouper prices while shark prices were relatively stable or declining. Examination of the trips by share of shark in total volume of catch indicates that there is been a notable shift in the concentration of activity away from shark products toward more diversified trips (McHugh and Murray, 1997).

Since 1983, the ex-vessel price for sharks has remained relatively stable at about $0.50 per pound in constant dollars after almost doubling from 1979 to 1983. However, nominal fin prices have risen significantly since 1987 in response to demand from Asia. During the 1995 fishing season, average carcass prices were around $0.80 per pound, while top quality fin prices held steady at around $18 to $26 per pound. The length of trips varies from less than four days to more than 12 days. Since the implementation of the FMP in 1993, trip lengths for the majority of trips have declined from over 12 days to under four days (an average per trip of eight days; McHugh and Murray, 1997). The shift to the snapper-grouper fishery, as noted above, is further evidence of the diversity of the shark fishery and the ability of participants to shift their product mix as regulatory, economic, or other factors change.

McHugh and Murray (1997) estimated profits per fishing trip for shark vessels as the owner's share of total catch minus all expenses other than those for food, which are normally taken out of the crew's share of the revenues. For the entire fishery, per-day profit rates were calculated, with a seven-day trip averaging $1,589 (for comparison with figures provided below). When examined by vessel category, vessels in the 40 to 49 foot range averaged $1975 in profits per seven-day trip ($282.18 in profits per day). A regression analysis shows that trip profitability is unrelated to the proportion of catch which is shark. Profits were also positively related to dummy variables for the 1994 and 1995 seasons, possibly indicating that the more efficient highliners remained in the fishery following implementation of the commercial retention limit. There is anecdotal evidence (supported in McHugh and Murray, 1997) that the implementation of the commercial retention limit rule resulted in the exit of some of the larger vessels from the shark fishery.

In another recent social and economic study (Larkin *et al*., 1998), slightly over one-third of the trips examined (approximately 15 percent of all trips) were conducted on vessels in the 30 to 49 foot category, which is likely most representative of vessels that would target and/or land sharks. In this size category, 30 percent of fish landed were sharks, as opposed to 12 percent for vessels in the 50 to 69 foot size category and two percent for vessels in the 70 to 89 foot size category. For these vessels, the average variable expenses per trip were $3,683 (including light sticks, which were probably used on swordfish-directed trips), while gross revenues ranged from $5,954 to $7,145. Total returns for a trip (payments to owner, captain, and owner) ranged from $2,271 to $3,462. With an annual average of 14.8 trips per year in this size range, these averages yield annual net revenues per vessel of $34,000 to $51,000, to be divided between the crew, captain (if not the same as the owner), and owner. The owner's share would need to cover insurance, depreciation, vessel maintenance, and other fixed costs. Since crews generally receive approximately 50 percent of the net revenues, and fixed costs are variable, it is uncertain whether the owner would be able to cover fixed costs and incur a net income.

Commercial shark fishing also generates economic activity in the processing, distribution and retailing sectors. Thus, shark fishery regulations can also impact non-fishing businesses. Although the 1993 FMP and its implementing regulations required shark vessel operators to offload their fins and carcasses at the same time, there appears to be an important market distinction between the shark fin and shark meat market that is evident at the time of offloading. Shark fin buyers are specialized operators who are highly skilled in the identification and grading of shark fins. In contrast, shoreside processors handling shark meat are most likely to handle the entire range of species harvested by the fleets in their area. Thus, fin buyers are likely more affected by changes in shark regulations than shark meat processors and distributors. McHugh and Murray (1997) indicate that shark fin buyers operate more like wholesalers than ex-vessel buyers, as their price negotiations with the vessel operator do not include the dealer who was the first receiver.

Dealers and shoreside processors purchasing directly from fishing vessels are required to obtain a NMFS dealer permit. On the dealer application form, applicants may check off boxes for the following species: reef fish, rock shrimp, snapper-grouper, shark, and swordfish. The permit costs $35 per year, regardless of the number of species indicated. Examination of the most recent dealer permit base reveals a total of 249 permit holders, of which 239 (96 percent) had checked off other species. Thus, similar to vessels, processors who handle sharks operate in a multispecies processing sector. Of the ten dealers handling exclusively sharks, four are located in Florida and three in Virginia. Based on information in the dealer database, 104 dealers (42 percent) are based in Florida, 22 (nine percent) in Louisiana, and 18 (seven percent) each in North Carolina and Texas. The geographical pattern of dealer permit holders is thus similar to that for vessel permit holders, although South Carolina and Massachusetts figure predominantly in the dealer permit base with 17 and 14 permits, respectively.

Recreational/Charter Fishing

Charter vessel fishing for sharks is becoming increasingly popular. In most U.S. waters, this type of fishing occurs from May to September. In some regions, certain species are heavily targeted, e.g., sharpnose and blacktip in the Carolinas, and makos and large white sharks at Montauk, NY. Many charter vessels also fish for sharks out of ports in Ocean City, MD and Wachapreague, VA. Headboats may land the smaller shark species, but they usually do not target sharks specifically, except for a headboat fishery for sharpnose sharks based in Port Aransas, TX.

Tournament participants observe the weigh-in of the day's catch. Photo credit: Dan Stawinski

Shark tournament fishing is usually conducted from vessels that vary in size from small outboards to sportfishing yachts of 15 meters or longer. The number of participants and vessels varies: a two-day Long Island, NY shark tournament has drawn 300 vessels and about 1,500 anglers annually in recent years, but some tournaments limit the number of vessels to less than 150 because of limited shore facilities. More exclusive tournaments charge high entry fees on a first-come, first-served basis, and offer a top prize of $50,000 or more. One major shark tournament in the mid-Atlantic, which has been held since 1988, offers prizes for the largest makos and blue sharks (with minimum sizes of 200 lbs and 150 lbs, respectively.) Nearly 200 vessels participate in this two-day tournament. Some tournaments encourage catch and release fishing by offering prize points for released sharks. The increase in eastern Gulf Coast shark fishing tournaments since 1973 underscores the popularity of this activity among anglers. Previously, there were only about a half dozen such tournaments in the region, but by the late 1980s there were about 65 each year (Casey, 1989).

Fisher and Ditton (1992) found that anglers spent an average of $197 per trip and were willing to spend on average an additional $105 rather than stop fishing for sharks. Given that most anglers release the fish that they catch, it is unlikely these estimates have changed substantially since 1992. Analyses presented at the 1998 SEW found that approximately 886 trips that caught a shark were sampled annually by the MRFSS survey from 1994 through 1996. Using these figures, a minimum estimate of the annual total spent by anglers who caught sharks is $174,542 and the annual angler consumer surplus is $93,030 for a minimum estimate of gross value of $267,572 per year. The number of trips that catch sharks would be higher than the number sampled, so this represents a minimum estimate of the economic impact of the shark recreational fishery. Fisher and Ditton (1992) also found that 32 percent of shark anglers said that no other species would be an acceptable substitute for sharks.

Non-Consumptive Uses of Sharks

In addition to the production and direct consumption of shark products, net benefits in the shark fishery are also derived from the existence value of sharks for non-consumptive user groups. Some people value knowing that sharks exist in the sea or value seeing sharks in the wild. The larger the wild stock of sharks, the greater this non-consumptive use value associated with the shark fishery. At present, quantitative estimates of existence value for sharks are unavailable. However, given the fascination by the public with sharks, it could be quite high. As an example of existence value, Cabot (1996) estimated the willingness to pay to recover the marine turtle populations at $33 per person or, if extrapolated, $8.3 billion for the nation. Existence value should be incorporated in the management decision-making process.

2.5 HMS Gear Types

This section describes the gears used to catch Atlantic highly migratory species. A discussion of bycatch of these gear types can be found in Section 3.5.

Fishermen made an estimated 206,806 trips targeting large pelagics (on private and charter vessels, both recreational and commercial) using rod and reel and handline during 1997. This estimate is only for trips made from Maine through Virginia. An additional 2,913 trips were estimated for North Carolina, but these were specifically for bluefin tuna. There are approximately 20,000 vessels permitted to use rod and reel, either recreationally or commercially, to fish for Atlantic tuna. The amount of gear used by these vessels, in terms of the number of rods and hooks, is unknown. Approximately 7,500 vessels are permitted to use harpoons to land Atlantic tuna; fewer than 100 of which are in the Harpoon category, the rest are in the General category. It is unknown how many trips are taken exclusively with harpoon gear.

Five vessels are permitted to use purse seine gear in the Atlantic tuna fishery. In 1996, 45 trips were taken by these vessels, on which 44 sets or hauls were made. Since the annual quota for the Purse Seine category has not changed since 1995, the amount of trips and sets per year has likely remained somewhat constant. In 1998, only four vessels landed bluefin tuna under the Purse Seine category quota (the fifth vessel transferred its quota to other vessels, as is permitted under the regulations), but the overall number of trips and sets for the category is most likely similar to those made in the years since 1996.

Approximately 40 vessels reported using coastal driftnets (other than pelagic) through the Northeast Region Dealer Reporting system in 1997. Twenty-six of these vessels reported landing Atlantic tuna (other than bluefin tuna), including Atlantic bonito. These vessels target species other than tuna, but catch tuna incidentally. It is unknown at this time how many trips or sets were made by these vessels, or how much gear was deployed.

Approximately 12 to 15 vessels use gillnets, typically 275 to 1,800 meters long and 3.2 to 4.1 meters deep, with stretched mesh from 12.7 to 29.9 cm, to fish for sharks in the southeast United States (off the Florida and Georgia coasts). Fishing trips are usually less than 18 hours long and in nearshore areas within 30 nautical miles from port. These vessels target large coastal sharks and small coastal sharks (primarily blacknose, Atlantic sharpnose, blacktip, and hammerhead) and have incidental catches of coastal pelagic finfishes (Trent *et al*., 1997).

During 1996, 264 pelagic longline vessels fishing for Atlantic swordfish deployed approximately 10.2 million hooks. Based on the eligibility criteria selected in the limited access system (see Chapter 4 for details), NMFS estimates that approximately 198 and 218 vessels are eligible for a directed and incidental swordfish permit, respectively, and that approximately 416 vessels are eligible for a BAYS longline permit.

Between 1994 and 1998, the Gulf and South Atlantic Fisheries Development Foundation's Observer Program observed the directed large coastal shark bottom longline fishery and documented details on the landings of about four percent of the large coastal shark quota. Approximately 5.5 million hook hours of effort caught more than 26,000 sharks with the average bottom longline sets lasting between 10.1 and 14.9 hours (GSAFDF, 1998). Based on the eligibility criteria selected in the limited access system (see Chapter 4 for details), NMFS estimates that approximately 211 and 578 vessels are eligible for a directed and incidental shark permit, respectively.

2.5.1 Pelagic Longlines

The U.S. pelagic longline fishery for Atlantic HMS primarily targets swordfish, yellowfin tuna, or bigeye tuna in various areas and seasons. Secondary target species include dolphin fish, albacore tuna, pelagic sharks (e.g., mako, thresher, blue and porbeagle sharks) as well as several species of large coastal sharks. Although this gear can be modified (i.e., depth of set, hook type, etc.) to target either swordfish or tuna, like other hook and line fisheries, it is a multi-species fishery. These fisheries are opportunistic, switching gear style and making subtle changes to optimize the net returns of each individual trip. Longline gear sometimes attracts and hooks non-target finfish with no commercial value, as well as species that cannot be retained by commercial fishermen, such as billfish. Pelagic longlines may also interact with protected species such as marine mammals, sea turtles and sea birds, and have thus been classified as a Category I fishery with respect to the Marine Mammal Protection Act.

A pelagic longline vessel based in New Bedford, MA that is a part of the distant water fishing fleet. Photo credit: Louis Jachimczyk, NMFS, Office of Law Enforcement

Pelagic longline gear is composed of several parts. The primary fishing line, or mainline of the longline system, can vary from five to 40 miles in length, with approximately 20 to 30 hooks per mile. This FMP limits the length of the mainline of a pelagic longline to 24 nautical miles from August 1 to November 30 in the Mid-Atlantic Bight through an interim measure. The depth of the mainline is determined by ocean currents and the length of the floatline, which connects the mainline to several buoys and periodic markers with radar reflectors and radio beacons. Each individual hook is connected by a leader to the mainline. Lightsticks, which contain chemicals that emit a glowing light, are often used. When attached to the hook and suspended at a certain depth, they attract bait fish which may, in turn, attract pelagic predators. When targeting swordfish, the lines generally are deployed at sunset and hauled in at sunrise to take advantage of the nocturnal near-surface feeding habits of the large pelagic species (Berkeley *et al*., 1981). In general, longlines targeting tuna are set in the morning, deeper in the water column, and hauled in the evening. Except for vessels of the distant water fleet which undertake extended trips, fishing vessels preferentially target swordfish during periods when the moon is full to take advantage of increased densities of pelagic species near the surface. Those sets targeting dolphin fish are set in the daytime near the surface, with shorter longlines and shorter soak time.

Secondary hook and line gear is permitted onboard pelagic longline vessels. Longliners use harpoons for safer handling of larger fish, and for the occasional harvest of free swimming fish that approach the vessel during haul-back. Using a technique known as "green sticking," fishermen may use a long pole to extend several longline leaders and hooks behind the vessel. Typically, this line is trolled while hauling the primary gear or while the vessel is moving on the fishing grounds. "Jigging machines" are a type of bandit gear used for trolling for HMS. Many pelagic longliners troll regular rod and reel gear while drifting to determine what species are available in the area they are passing through.

Reported effort, in terms of number of vessels fishing, has fluctuated in recent years but has not shown obvious trends in the distant water, southeast coastal, and northeast coastal areas. However, there appears to be a trend towards decreasing numbers of vessels fishing in the Caribbean and the Gulf of Mexico. In all areas, the reported number of hooks per set has increased. Although swordfish appear to have remained the primary target species in the Caribbean, distant water, and southeast coastal fishery areas, the proportion of swordfish in the reported landed catch has decreased in both the distant water and southeast coastal areas. In the case of the distant water fishery, an increasing proportion of the reported landings are BAYS tuna. Coastal shark and dolphin landings have increased in the southeast coastal area. The largest decreases in targeting and landing of swordfish were in the northeast coastal area (Cramer and Adams, 1997). The Gulf of Mexico, which has historically been primarily a yellowfin tuna fishery, has had an increase in reported targeting and landing of swordfish in recent years (Cramer and Scott, 1998).

The pelagic longline fishery sector is comprised of five relatively distinct segments with different fishing practices and strategies. Each vessel type has different range capabilities due to fuel capacity, hold capacity, size, and construction. In addition to geographical area, segments differ by percentage of various target and non-target species, gear characteristics, bait, and deployment techniques. Some vessels fish in more than one fishery segment during the course of the year.

The Gulf of Mexico Yellowfin Tuna Fishery

These longline vessels primarily target yellowfin tuna year-round in the Gulf of Mexico, but may also catch and sell dolphin fish, swordfish, and other tuna and sharks. During yellowfin tuna fishing, few swordfish are captured incidentally. Many of these vessels participate in other Gulf of Mexico fisheries (targeting shrimp, shark, and snapper/grouper) during allowed seasons, which may require a change in gear. Major home ports for this fishery include Panama City, FL; Destin, FL; Dulac, LA; and Venice, LA.

The Southern Atlantic ~ Florida East Coast to Cape Hatteras Swordfish Fishery

These pelagic longline vessels primarily target swordfish year-round. Yellowfin tuna and dolphin fish are other important marketable components of the catch. Smaller vessels fish shorter trips from the Florida Straits north to the bend in the Gulf Stream off Charleston, SC (Charleston Bump). Mid-sized and larger vessels migrate seasonally on longer trips from the Yucatan Peninsula throughout the West Indies and Caribbean Sea and some trips range as far north as the mid-Atlantic coast of the United States to target bigeye tuna and swordfish during the late summer and fall. Fishing trips in this fishery average nine sets over 12 days. Major home ports (including seasonal ports) for this fishery include Georgetown, SC; Cherry Point, SC; Charleston, SC; Fort Pierce, FL; Pompano Beach, FL; Dania, FL; and Key West, FL. This sector of the fishery consists of small to mid-size vessels that typically sell fresh swordfish to local high-quality markets.

The Mid-Atlantic and New England Swordfish and Bigeye Tuna Fishery

This fishery has evolved during recent years to become an almost year-round fishery based on directed tuna trips, with substantial numbers of swordfish trips as well. Some vessels participate in the directed bigeye/yellowfin tuna fishery during the summer and fall months and then switch to bottom longline fisheries and/or shark fishing during the winter when the shark season is open. Fishing trips in this fishery sector average 12 sets over 18 days. During the season, vessels primarily offload in the major ports of Fairhaven, MA; Montauk, NY; Barnegat Light, NJ; Ocean City, MD; and Wanchese, NC. Some of these vessels follow the swordfish along the mid-Atlantic coast, then fish off the coast of the southeast United States during the winter months.

The U.S. Atlantic Distant Water Swordfish Fishery

This fleet's fishing grounds span the northwest Atlantic to as far east as the Azores and the mid-Atlantic Ridge. Some of the larger vessels have moved beyond this area and into the south Atlantic Ocean. About ten larger vessels operate out of mid-Atlantic and New England ports during the summer and fall months, and move to Caribbean ports during the winter and spring months. Many of the current distant water operations were among the early participants in the U.S. directed Atlantic commercial swordfish fishery. These larger vessels, with greater ranges and capacities than the coastal fishing vessels, enabled the United States to become a significant player in the north Atlantic fishery. They also fish for swordfish in the south Atlantic. The New England longline vessels traditionally have been larger than their Florida counterparts because of the distances required to travel to the fishing grounds. The larger sized vessels allow more time at sea. A typical New England longline vessel generally ranges from 60 to 80 feet in length, and fishes off New England in the summer and fall. As winter approaches, these vessels work their way southward. Fishing trips in this fishery tend to be longer than in other fisheries, averaging 30 days and 16 sets. Principal ports for this fishery range from San Juan, PR through Portland, ME, and include

Fairhaven, MA, and Barnegat Light, NJ. There have been approximately ten to fifteen distant water vessels in recent years, reduced from a peak of 60 to 70 vessels in the late 1980s and early 1990s.

The Caribbean Island Tuna and Swordfish Fishery

This fleet is similar to the southeast coastal fishing fleet in that both are comprised primarily of smaller vessels that make short trips relatively near-shore, producing very high quality fresh product. Both fleets also encounter relatively high numbers of undersized swordfish at certain times of the year. Longline vessels targeting highly migratory species in the Caribbean use fewer hooks per set, on average, fishing deeper in the water column than the distant water fleet off New England, the northeast coastal fleet, and the Gulf of Mexico yellowfin tuna fleet. This fishery is typical of most pelagic fisheries, being truly a multi-species fishery, with swordfish as a substantial portion of the total catch. Yellowfin tuna, dolphin fish, and, to a lesser extent, bigeye tuna, are other important components of the landed catch. Principal ports are St. Croix, USVI and San Juan, PR. Many of these high-quality fresh fish are sold to local markets to support the tourist trade in the Caribbean.

2.5.2 Bottom Longlines

The Atlantic bottom longline fishery targets large coastal sharks, with landings dominated by sandbar and blacktip sharks. Gear characteristics vary slightly by region, but in general, a ten-mile long monofilament bottom longline, containing about 750 hooks, is fished overnight. Skates, sharks, or various finfishes are used as bait (GSAFDF, 1997). The gear typically consists of a heavy monofilament mainline with lighter weight monofilament gangions. Some fishermen may occasionally use a flexible 1/16 inch wire rope as gangion material or as a short leader above the hook.

Commercial shark fishing effort with bottom longline gear is concentrated in the southeastern United States and Gulf of Mexico. McHugh and Murray (1997) found in a survey of shark fishery participants that the largest concentration of bottom longline fishing vessels is found along the central Gulf coast of Florida, with the John's Pass - Madeira Beach area considered the center of directed shark fishing activities. In 1996, the greatest number of shark permits was issued in Florida (63 percent), followed by Louisiana and North Carolina (seven percent each). Focusing on the 565 permit holders who landed at least one large coastal shark in 1995 or 1996 ("active" permit holders), Florida is the lead state, with over 61 percent of active permit holders, followed by Louisiana and North Carolina with eight and seven percent, respectively. Of the 40 vessels that cumulatively caught half the reported landings, 55 percent listed Florida as their home state, followed by North Carolina at 15 percent, and Louisiana at ten percent. As with all HMS fisheries, some shark fishery participants move from their home ports to active fishing areas as the seasons change.

Between 1994 and 1997, the Gulf and South Atlantic Fisheries Development Foundation's Observer Program observed 5.5 million hook hours of effort that caught more than 26,000 sharks (GSAFDF, 1997). Their observations indicated that average bottom longline sets lasted between 10.1 and 14.9 hours, with longer sets typical of the North Carolina and Florida Gulf fisheries and shorter sets typical of the South Carolina/ Georgia fishery. North Carolina fishermen, on average, set the longest lines (13.7 miles), followed by the Florida Gulf (10.5 miles) and the South Carolina/Georgia fishery (6.9 miles).

According to findings of the GSAFDF's Observer Program, sandbar and blacktip sharks dominated catches of large coastal sharks. Depending on region and year, they constituted 60 to 75 percent of the catch and 75 to 95 percent of the landings during the period 1994 to 1996. Tiger sharks were the third-most common large coastal sharks caught during the three-year period. However, the tiger shark has little market value and is usually discarded; a few were landed, and some small individuals were used as bait. Other species, such as dusky, bull, and lemon sharks were found to be of local importance. Five species (sandbar, blacktip, dusky, bull, and lemon sharks) constituted 95 percent of the landings. Vessels operating in the South Atlantic Bight caught and landed a greater diversity of species than other regions.

2.5.3 Atlantic Pelagic Driftnets

Pelagic driftnets are set anywhere from mid-water to the surface and drift with tide and wind conditions. The vessel stays with one end of the net to ensure that the net remains stretched. Several driftnets may be set end to end in a string. Pelagic driftnets are best described as "entanglement" nets, rather than gillnets, since the objective is to entangle, rather than gill, the target fish. Driftnet fishing for large pelagics is most common at night, with soak times averaging 12 hours. Fishermen prefer fishing when the moon is dark to prevent detection of the net by target species. Schools of fish are not specifically targeted with this gear; however, nets are set near oceanographic thermal fronts where large pelagic fish congregate. During swordfish seasons in the past, driftnet gear was typically 20 to 22 inch mesh size, 60 to 70 meshes deep, set 18 to 30 feet below the surface, and with a floatline length of 1.5 miles. The Magnuson-Stevens Act limits the length of the net to 2.5 km (approximately 1.6 miles).

Although the swordfish driftnet quota was not reached in 1998, NMFS did not reopen the fishery due to high bycatch rates of endangered sea turtles and marine mammals. In January 1999, NMFS prohibited the use of driftnets in the Atlantic swordfish fishery, including the possession of any swordfish when a driftnet was on board a vessel (e.g., in the case of a tuna driftnet trip). This FMP further prohibits the use of driftnets in the tuna fishery, although vessels which target other species using driftnets may apply for an exempted fishing permit in order to retain incidentally caught Atlantic tunas (other than bluefin tuna). To date, no driftnet sets have been made in sole pursuit of sharks although NMFS has received inquiries as to the possibility of this fishery. A New England pelagic driftnet shark fishery might further exacerbate bycatch problems with this gear. However, NMFS does not anticipate driftnet trips taken to pursue sharks given the limited quota for large coastal sharks and the requirement to discard all tunas and swordfish. If further action is needed to limit the use of driftnets, NMFS will consider further rulemaking.

2.5.4 Atlantic Coastal Driftnets

Atlantic tunas other than bluefin tuna are sometimes caught in driftnet fisheries other than the pelagic driftnet fishery. According to NMFS' Northeast Regional Office dealer reports, approximately 40 vessels reported using driftnets (other than pelagic) in 1997, down from about 50 vessels in 1996. In 1997, 26 of the vessels reported landing bonito and/or bigeye, albacore, yellowfin, skipjack (BAYS) tunas, with 14 reporting landing BAYS tunas. In 1996, 31 of the vessels reported landing bonito and/or BAYS tunas, with 16 reporting BAYS tuna landings. The mesh size of the gear used by these vessels is generally smaller than six inches, and the fishery takes place mainly off southern New England and the mid-Atlantic region from Rhode Island to North Carolina during the summer and early fall, with the majority of landings occurring in New Jersey and New York. The mesh size of the gear used is generally smaller than six inches, and Table 2.49 presents the landings of these vessels for 1996 and 1997. Landings of BAYS tuna made up less than one percent of the total landings reported, while landings of dogfish and bluefish made up over 40 percent and approximately 20 percent, respectively, of the total landings. Other species that made up a significant portion of these vessels' total landings include monkfish and weakfish.

The landings of BAYS tunas by non-pelagic driftnet gear make up a relatively small portion of the total U.S. landings of these species. The 1998 U.S. National Report to ICCAT reports composition of total U.S. landings by non-pelagic driftnets as follows: skipjack - about 9.4 percent; albacore - approximately 2.5 percent; yellowfin and bigeye - less than 0.1 percent each.

Data are also available from 51 observed trips using coastal driftnets from 1996 through 1998. In slight contrast to the dealer-reported data, the observer data indicate that bluefish are the main species caught using this gear type, accounting for over 65 percent of the retained catch. Bonito were the second most significant part of the catch, accounting for 11.5 percent of the retained catch. BAYS tunas accounted for less than one-half of one percent of the retained catch for these observed trips. For bycatch of this gear type, refer to Section 3.5. The FMP bans this type of gear for BAYS, but NMFS will allow exempted fishing permits while the agency studies the fishery over the next few years.

Table 2.49 Reported landings of Atlantic tuna for vessels using non-pelagic driftnets, in pounds, 1996 - 1997. (NMFS Northeast Regional Office Dealer Weighout Reports)

	BAYS Tunas	Skipjack	Albacore	Yellowfin	Bigeye	Bonito	Other Tunas	Total Catch
1996	35,289	14,976	19,304	1,009	0	204,883	5,690,356	5,725,645
1997	50,224	32,540	17,105	339	240	150,813	5,590,585	5,640,809

2.5.5 Southeast Shark Drift Gillnets

Gillnet fishing for sharks in the southeast United States (Florida and Georgia coasts) has existed for many years. NMFS conducted an observer program in the southeast shark drift gillnet fishery from 1993 to 1995 (Trent *et al*., 1997). The following information is taken from those observer data. This fishery is comprised of 12 to 15 vessels approximately 12.2 to 19.8 meters long that used nets typically 275 to 1,800 meters long and 3.2 to 4.1 meters deep, with stretched mesh from 12.7 to 29.9 cm. Fishing trips are usually less than 18 hours long and in nearshore areas within 30 nautical miles from port. The number of vessels in the fishery increased from five to 11 from 1993 to 1995, but the total number of trips decreased from 185 in 1994 to 149 in 1995. From 1993 to 1995, 48 trips and 52 net sets were observed. Eight shark species made up over 99 percent of sharks caught including, in order of abundance by weight: blacknose, Atlantic sharpnose, blacktip, finetooth, scalloped hammerhead, bonnethead, spinner, and great hammerhead. Ten species of finfish and rays made up over 97 percent of the non-shark catch including, in order of abundance: king mackerel, little tunny, cownose ray, crevalle jack, cobia, spotted eagle ray, great barracuda, tarpon, Atlantic stingray, and Spanish mackerel (Trent *et al.*, 1997).

From 1996 through the first fishing period of 1998, no observers were placed on shark drift gillnet vessels due to problems with observer placement (observers were not able to view the haul back of the gear) that have since been resolved. Beginning in the second fishing period of 1998, shark drift gillnet fishermen were reminded of the requirement to notify NMFS of trips and to carry observers. Seven trips were observed on five vessels in the second period of 1998. Recent legislation in South Carolina, Georgia, and Florida has prohibited the use of commercial gillnets in state waters, thereby forcing some of these vessels into deeper waters under Federal jurisdiction, where gillnets are less effective. This FMP requires 100 percent observer coverage in the shark drift gillnet fishery at all times, and prohibits the use of gillnets to fish for sharks unless a NMFS-approved observer is aboard.

2.5.6 Sink Gillnets

A sink gillnet fishery along the north Atlantic coast lands Atlantic bonito and little tunny. In terms of catch composition and areas and times in which it takes place, this fishery is similar to that of the coastal driftnet fishery described above. In 1997, 27,751 lbs of Atlantic bonito, valued at $19,203, were landed using sink gillnets by 27 vessels on 244 trips (see Table 2.50). On one of these trips little tunny was also landed.

Table 2.50 Sink gillnet bonito fishery, 1997. (NMFS Northeast Weighout Database (NMFS, 1997b))

State	# of Vessels	# of Trips	Pounds	Value
Maryland	1	1	7	1
Massachusetts	3	6	342	79
New Jersey	4	5	135	125
New York	14	192	26,686	18,801
Rhode Island	4	8	513	152
Virginia	1	2	68	45
TOTAL	**27**	**214**	**27,751**	**19,203**

2.5.7 Purse Seines

U.S. vessels fishing for Atlantic tuna with purse seine gear originally operated from several ports in the northeastern United States, California, and Puerto Rico. The fishery traditionally targeted small and medium tuna in nearshore waters (rarely outside 200 km) between Cape Hatteras and Cape Cod in the summer, and giant tuna in the Gulf of Maine in late summer and early fall for the cannery industry. Currently, purse seiners target bluefin tuna within 75 miles of the New England coast and BAYS tunas in federal waters off the mid-Atlantic coast. A combination of quota regulations and over-investment in fishing capacity has strictly limited the duration of the fishing seasons.

In 1982, a limited entry system with non-transferable individual vessel quotas (IVQs) for purse seining was established, effectively excluding any new entrants to this category. Equal quotas are assigned to individual vessels by regulation; the IVQ system is possible given the small pool of ownership in this sector of the fishery. Currently, the Atlantic bluefin tuna purse seine fleet is limited to five vessels. In the past, larger distant-water seiners from the U.S. Pacific coast and Canada occasionally diverted operations from the yellowfin and skipjack tuna fisheries to fish for bluefin tuna, but this practice is no longer permitted. These larger vessels may have been less efficient in the shallow shelf waters of the northwest Atlantic than the smaller purse seine vessels currently involved in the fishery.

Prior to the establishment of the limited access system, up to 21 purse seine vessels participated in the fishery, landing upwards of 5,000 mt of bluefin on an annual basis. When the limited access system for the Purse Seine category was first established in 1982, the five vessels which were allowed to continue participating in the fishery reflected those participating at the time. Currently, while only five vessels participate in the fishery, approximately 60 people earn a significant portion of their annual income working on the Purse Seine category vessels fishing for bluefin. This does not include the spotter pilots, dealers, processors, freight forwarders, and others who derive part of their income from the purse seine fishery. Three of the Purse Seine category vessels land their catch in New Bedford, MA, a community which is very dependent on fishing. The other two Purse Seine category vessels land their bluefin in Gloucester and Sandwich, MA, communities which are also dependent on fishing for their economic and social livelihood. Only one of the currently permitted Purse Seine category vessels participates in other commercial fisheries.

The nets and other associated gear used for purse seining are expensive and very specialized, and it may not be cost effective to refit the vessels for other fisheries.

Atlantic tuna purse seining operations typically use spotter aircraft to locate fish schools. The vessels may not even leave the docks until suitable concentrations of fish are located. Although the season officially opens August 15, the actual start of the seining fishing season coincides with availability of fish in schools large and dense enough to offset fishing costs. It is interesting to note that, in contrast to the other commercial categories, the use of IVQs has eliminated the "race to the fish" in the Purse Seine category. Once sufficient densities of fish appear and the fat content is suitable for the market, catch rates are generally high and the annual quota for large medium and giant bluefin tuna is usually met within weeks. While bluefin tuna is the primary target of the Purse Seine category fishery, opportunistic catch of skipjack and yellowfin tuna can be an important addition to total annual catch. This FMP sets the Purse Seine category quota at 18.6 percent of the total U.S. quota for bluefin tuna, with a cap of 250 mt (divided evenly into five IVQs of 50 mt), of which a minimum of 90 percent are giant bluefin tuna (greater than 81 inches) and ten percent may be large medium bluefin tuna (73 to 81 inches). In addition, purse seiners are limited to a one percent bycatch limit on undersized bluefin tuna (lesser than 73 inches) which cannot be sold. Any bycatch of undersized bluefin tuna by these same vessels when targeting yellowfin or skipjack tuna is included in this one-percent limit. Purse seine vessels cannot target other tunas unless they have bluefin tuna quota available, in case of bycatch.

2.5.8 Handgear (Rod and Reel, Handline and Harpoon)

The handgear fishery for HMS includes private vessels, charter vessels, and headboat vessels. Details of operations, frequency and duration of trips, and distance ventured offshore by recreational fishermen vary widely. The handgear fishery for tuna is composed of a diverse collection of vessels and fishermen. Most of the vessels are greater than seven meters in length and are privately owned by individual fishermen. Charter/headboats have been targeting school bluefin tuna off New York and New Jersey since the early 1900s. A recent survey of anglers that participated in the 1997 winter fishery off Cape Hatteras, NC found that 73 percent of 1,390 vessel trips for bluefin tuna were taken on charterboats (Ditton *et al*., 1998). Small bluefin tuna are typically caught by trolling with artificial lures, although chunking has become popular in some areas, using rod and reel. Giant bluefin tuna are harpooned (a commercial fishery), or are caught by trolling, or by chumming and drifting with several types of hook and line gear. Mackerel, whiting, mullet, ballyhoo, and squid are the usual choices for bait.

Recreational fishing for medium and giant bluefin tuna with rod and reel generally takes place between December and February off North Carolina. Smaller bluefin tuna are targeted off Virginia, Delaware and Maryland in early to mid-summer, with the center of activity moving northward into the New York Bight as the season progresses. Giant bluefin tuna are caught with handgear in Cape Cod Bay, the Gulf of Maine, and other New England waters during summer and early fall. Fishing usually takes place between eight and 200 km from shore. Beyond these general patterns, the availability of bluefin tuna at a specific location and time is highly dependent on environmental variables that fluctuate from year-to-year. Tournaments tend to concentrate fishing effort into a small area.

The proportion of domestic HMS landings that is harvested with handgear varies by species. In 1997, the amount of yellowfin tuna harvested with handgear in the northwest Atlantic was roughly three times the amount harvested by longlines. The yellowfin tuna recreational fishery is often the "staple" fishery for fishermen along the Atlantic coast. Yellowfin tuna are often available for a long summer fishing season, and are sought for consumption by many recreational fishermen. During 1997, handgear was used to harvest 71 percent of total U.S. skipjack tuna landings. Only 27 percent of total U.S. bigeye tuna landings in 1997 were attributed to handgear, with most activity occurring in rod and reel fisheries between Cape Hatteras and Massachusetts. Approximately one-third of U.S. landings of albacore tuna were caught with handgear in 1997. There are minimal data available on current rod and reel fishing for swordfish. In 1997, only 15 swordfish encountered by rod and reel fishermen were reported to the Large Pelagic Survey.

Harpoon vessels formerly operating out of Rhode Island and Massachusetts traditionally took extended trips for swordfish north and east of the Hudson Canyon and particularly off Georges Bank, landing as many as 20 to 25 large swordfish over a ten-day period. Due to decreased availability of the large swordfish they target, there are no known commercial harpoon fishermen (who use only harpoons) who have both a current permit and the specified landings required for a directed permit. As part of the limited access program implemented in this FMP, NMFS will issue a handgear permit to those fishermen who provide documentation of having been issued a swordfish permit for use with harpoon gear or those who landed swordfish with handgear as evidenced by logbook records, verifiable sales slips or receipts from registered dealers, or state landings records. NMFS will also issue handgear permits to those applicants who meet the earned income requirement, i.e., those who had derived more than 50 percent of their earned income from commercial fishing through the harvest and first sale of fish or from charter/headboat fishing, or those who had gross sales of fish greater than $20,000 harvested from their vessel, during one of the three calendar years preceding the application. See Chapter 4 for a description of the handgear permit for swordfish under the limited access system.

In the past, sharks were often called "the poor man's marlin." Recreational shark fishing with rod and reel is now a popular sport at all social and economic levels, largely because of accessibility to the resource. Sharks can be caught virtually anywhere in salt water, with even large specimens available in the nearshore area to surf anglers or small boaters. Most recreational shark fishing takes place from small to medium-size vessels. Makos, white sharks, and large pelagic sharks are generally accessible only to those aboard ocean-going vessels. Recreational shark fisheries are exploited primarily by private vessels and charter/headboats although there are some shore-based fishermen active in the Florida Keys.

2.6 Current Permitting, Reporting, Data Collection Requirements and Fisheries Monitoring

Monitoring programs form the foundation of effective management in both commercial and recreational fisheries. NMFS strives to ensure that this information: 1) is collected and processed efficiently; 2) avoids duplication or redundancy; 3) is compatible with other data sources; 4) is secure; 5) minimizes burdens on those reporting; 6) is complete and accurate; 7) is statistically valid and internally consistent; 8) is relevant and responsive to users' needs; and 9) is available on a timely basis. Data collection efforts must meet the requirements of the Atlantic Tunas Convention Act. NMFS has published a comprehensive research and monitoring plan for HMS which will be updated on an annual basis.

Commercial logbook data, including catch and effort statistics, discards, and locations of catches, are used to estimate catch per unit effort and discard rates of target and bycatch species. Data from licensed Atlantic tuna, swordfish, and shark dealers are used primarily for quota monitoring, but statistics on fish lengths and weights may also be used to determine average weights at size, which can vary substantially from year to year. At-sea observer programs provide detailed information on the locations of fishing activities, fishing effort expended per unit time, other factors affecting fishing success, the composition of fish catches, species, sizes and amounts retained, biological condition of captured fish, and discard rates of target and bycatch species. Land-based surveys of recreational fisheries, including dockside intercept surveys and telephone surveys, provide similar information on recreational fisheries. These data on catch and effort are used to develop standardized indices of catch per unit effort which, in turn, are used as indices of relative stock abundance in stock assessment models.

While data collection is carried out primarily by NMFS, monitoring and research on large pelagics is conducted by a combination of government, academic, and to a lesser extent, private research entities. Research priorities are gleaned from SCRS annual reports; recommendations from the Advisory Committee to the U.S. Section of ICCAT; recommendations from the HMS, Billfish, and Longline Advisory Panels; recommendations from the Shark Evaluation Workshops, and from interaction among researchers, fishery managers and constituents. The primary objective of the research and statistics program is to improve the knowledge base necessary to design, implement, and monitor domestic and international management measures.

2.6.1 Monitoring and Reporting in the Commercial Fishery

Commercial fisheries for Atlantic tunas, sharks, and swordfish are monitored through a combination of vessel logbooks, dealer reports, port sampling, cooperative agreements with states, and scientific observer coverage. Logbooks contain information on fishing vessel activity, including dates of trips, number of sets, area fished, number of fish and other marine species caught, released and retained. In some cases, social and economic data such as volume and cost of fishing inputs are provided. Monitoring of U.S. high seas commercial fisheries for large pelagics will be further enhanced by the requirement for a Vessel Monitoring System (VMS), which is described in Section 3.8. Observer coverage for HMS fisheries is also described later in this section.

Vessel and Dealer Permitting and Reporting

Currently all commercial vessels that hold HMS permits are required to display the official number of the vessel so as to be clearly visible from an enforcement vessel or aircraft. Vessel permits for commercial and recreational vessels targeting Atlantic tunas (bluefin, yellowfin, bigeye, albacore, and skipjack) must be renewed on an annual basis. NMFS has issued approximately 20,000 Atlantic tuna vessel permits under an automated permitting system that was implemented in 1997.

Annual permits are also required for U.S. commercial vessels fishing for swordfish and for those commercial vessels fishing for Atlantic sharks in the U.S. Exclusive Economic Zone (EEZ). This FMP implements a two-tiered limited access permit system for directed and incidental longline fishing for swordfish, sharks and BAYS tunas based on current and historical participation in these fisheries. The limited access program requires pelagic longline vessels targeting tuna or swordfish to have tuna, shark, and swordfish permits (either directed or incidental.) Longline vessels targeting sharks must have a shark permit (either directed or incidental.) The limited access program is intended to stabilize the fleet size and provide an opportunity for NMFS to collect data, conduct studies, and work cooperatively with constituents to develop a flexible, and permanent, effort control program. See Chapter 4 for a detailed description of the limited access program for HMS.

Dealer permits are required for the commercial receipt of Atlantic tuna, swordfish, and sharks. A separate dealer permit is required for each of the fisheries. Bluefin tuna dealers report imports through the Bluefin Statistical Document, as described below, while swordfish dealers report through the dealer import form. Permits for dealers to purchase species in the swordfish or shark management unit are issued by the NMFS Southeast Regional Office and permits for the Atlantic tuna fishery, including bluefin tuna, are issued by the NMFS Northeast Regional Office through a government contractor. Dealer permits for sharks and swordfish are issued for a 12-month period from the first of the month following the month in which the business was incorporated. Atlantic tuna dealer permits are issued for a calendar year (January 1 through December 31). Dealer reports must be submitted to NMFS twice a month for all swordfish, sharks and tunas.

Swordfish semi-annual commercial quotas are monitored through a combination of vessel logbooks, tally sheets, port sampling, dealer reports, and scientific observer coverage. Logbooks contain information on fishing vessel activity, including dates of trips, number of sets, area fished, and the number of marine species caught, released, and retained. In some cases, social and economic data such as volume and cost of fishing inputs are also provided. Daily logbooks must be completed within 48 hours of a trip and postmarked within seven days of sale of the swordfish and/or tuna off-loaded from a trip. Copies of tally sheets must be submitted with the logbook forms. If no fishing occurred during a month, a report so stated must be submitted in accordance with instructions provided with the logbook forms ("zero reporting"). In October 1997, NMFS implemented the same management measures for the south Atlantic swordfish stock that are currently in place for the north Atlantic swordfish stock, including vessel permitting, logbook reporting, and observer requirements.

NMFS collects shark data through reports from owners/operators of permitted vessels under a mandatory commercial logbook program and the shark fishery observer program. Commercial landings data for sharks are also collected by seafood dealers and port agents who routinely record the weight and average ex-vessel price of sharks. Species-specific catch and landings statistics for sharks are problematic, since there are many similar species and identification of dressed sharks is difficult. To increase species-specific reporting, NMFS intends to develop a field guide for sharks to assist fishermen in the identification of species for the required catch reports. NMFS is required by the Biological Opinion to work cooperatively with the Florida Department of Environmental to compare shark drift gillnet landings data from various sources. This is necessary to better determine actual effort levels for improved sea turtle take estimates and to assess what effort levels may be occurring in the area during right whale season.

Monitoring of the commercial bluefin tuna fishery is conducted primarily through the dealer reporting system. Dealers are required to record each purchase of Atlantic bluefin tuna on a landing card and provide the information to NMFS within 24 hours of the purchase or receipt of the fish. The landing cards, which are used to monitor the bluefin tuna quota, include the following information: dealer number, dealer name, date the fish was landed, harvest gear, fork length, weight (whole or dressed), identification tag number, area where fish was caught, port where landed, Atlantic tuna permit number, vessel name, and the name and dated signature of the vessel's master. In 1998, NMFS began using FAX/Optical Character Recognition (OCR) technology for bluefin tuna landing cards in order to facilitate data entry and quota monitoring. Bluefin tuna dealers are also required to submit summary reports to NMFS on a biweekly basis, which provide additional economic data including the destination of the fish, price per pound, and quality rating.

While there are currently no commercial quotas for tunas other than bluefin tuna, commercial catches of these species are monitored through a combination of vessel logbooks, port sampling, dealer reports, and scientific observer coverage. Vessels are required to report catches of Atlantic tunas in their logbooks, and dealers are required to report receipt of Atlantic tunas on their dealer report forms. Commercial landings information on Atlantic tunas is enhanced through cooperative agreements with states that report fisheries information to NMFS and through a port agent network in the Northeast that covers Virginia through Maine.

Trade Monitoring

NMFS is active in monitoring imports and exports of HMS. NOAA Form 370, the Fisheries Certificate of Origin, is currently used to monitor imports of tuna and other fish products to certify that the fish were not harvested by methods injurious to dolphins. It is not required for fresh fish shipments but is a requirement for all frozen tuna shipments entering his country. The NOAA Form 370 may be submitted to Customs through electronic filing.

As described in Section 2.2.4, all bluefin tuna (Atlantic and Pacific) imported to, or exported from, the United States must be accompanied by a Bluefin Statistical Document

(BSD) in order to meet the requirements of ICCAT's BSD Program. The purpose of the BSD is to track bluefin tuna trade as a means to improve the reliability of statistical information on bluefin tuna landings, since a considerable number of vessels fishing for bluefin tuna are registered to non-member nations and not all nations fully report their landings to ICCAT. In 1996, 9,429 mt of bluefin tuna were added to the reported ICCAT landings in the eastern Atlantic and Mediterranean based on BSD reports. In the United States, the completed BSD must be sent to the NMFS Northeast Regional Office within 24 hours of a bluefin tuna shipment (Atlantic or Pacific) entering or leaving the country. Information collected through the BSD program is reported to ICCAT on a semi-annual basis and is used to assess total bluefin tuna mortality as well as compliance with quotas.

The Certificate of Eligibility (COE) program for swordfish tracks the country and ocean of origin of swordfish, and validates that if the shipment contains Atlantic swordfish or swordfish parts, they are derived from swordfish weighing more than the U.S. minimum size of 33 lbs dw. These regulations are designed to facilitate the collection of information relating to the trade in Atlantic swordfish which may hinder conservation efforts by the United States and ICCAT.


Small swordfish are sometimes encountered by commercial fishing vessels. Photo credit: Dan Stawinski

A Memorandum of Understanding (MOU) has recently been developed between U.S. Customs and NMFS to facilitate the transmission of U.S. Customs data related to bluefin tuna and swordfish trade on a monthly basis. NMFS has requested import data on fresh, chilled, or frozen bluefin tuna and swordfish. Swordfish products in all forms (e.g., fresh and frozen steaks, frozen fillets) are subject to ICCAT import monitoring requirements. Data received under this MOU include port of entry, importer, consignee, weight of shipment, country of origin, and type of shipment. These data help NMFS identify major importers and exporters and points of entry for various swordfish product forms. NMFS works with U.S. Customs to enforce trade restrictions on HMS (e.g., bluefin tuna from Panama, Belize, and Honduras). The MOU also helps NMFS to verify the bluefin tuna import data it receives from dealers and identify those importers not in compliance with the BSD program. Aggregated data on import, export, and re-export of HMS, including countries of origin, product form, and weight and value of shipments, are available to the public through the website of the NMFS Division of Statistics and Economics (http://kingfish.ssp.nmfs.gov).

Observer Coverage

This FMP requires observer coverage of all the commercial fisheries that target HMS. However, all vessels from a particular sector may not be selected for observer coverage based on sampling design or objectives of the program in a particular year. At-sea observer programs allow NMFS to collect information on the conduct of the fishery and the type (species, size, condition) and amount of total catch, both landed and discarded, from the fishery. Given the multispecies nature of HMS fisheries and the overfished condition of several target species, collection of such information will be helpful in meeting the objectives of this FMP and the requirements of the Magnuson-Stevens Act.

Scientific observer coverage of the U.S. pelagic longline fleet was initiated by NMFS in 1992. Government contractors and NMFS observers collect catch data on pelagic longline vessels fishing in the waters of the northwest Atlantic Ocean, Gulf of Mexico, and Caribbean Sea. An ICCAT recommendation requires five percent observer coverage of vessels fishing for yellowfin and bigeye tuna. Selection of U.S. vessels is a random, five percent target sampling based on the fishing vessel performance information provided through mandatory pelagic logbooks. The NMFS' Southeast Fisheries Science Center and NMFS' Northeast Fisheries Science Center successfully recorded effort from 652 sets during 1994, 699 sets during 1995, 362 sets during 1996, and 460 sets during 1997. Observers from the NMFS' Southeast Fisheries Science Center have recorded over 50,000 fish (primarily swordfish, tuna, and sharks), marine mammals, turtles, and seabirds during this time period. NMFS is required under the ESA to have five percent coverage of the pelagic longline fleet, and during certain times and in certain areas, 100 percent coverage of the shark drift gillnet fleet. This FMP requires 100 percent observer coverage for the southeast shark drift gillnet fleet.

Additional data on sex ratio at size for Atlantic swordfish have been collected since 1989 by the NMFS' Southeast Fisheries Science Center in cooperation with volunteer captains in the U.S. longline fleet. Scientific observers and cooperative vessel captains and crews have provided biological material for analysis of swordfish reproductive behavior, age and growth, and stock structure identification. Morphometric (length and weight) and other biological data have primarily been collected within the range of U.S. vessels operating in the western Atlantic Ocean, Gulf of Mexico, and Caribbean Sea. Additionally, swordfish data have been collected by the ICCAT-sponsored Venezuelan observer program aboard Venezuelan longline vessels fishing the lower Caribbean Sea since 1991.

Since 1994, NMFS has provided funds to the Gulf and South Atlantic Fisheries Development Foundation (GSAFDF) and the University of Florida to run an observer program for the southeast U.S. commercial shark longline fishery. Additional funding was provided through a Saltonstall-Kennedy grant in 1996. The program collects information on catch and effort, size/age and sex composition of the catch, landings, discards, and other biological information about the catch. The program is responsible for developing what is believed to be the largest biological database in existence for western North Atlantic sharks. The voluntary program documented two percent of U.S. commercial shark landings during the 1994 to 1997 period, observing 5.5 million hook-hours of effort and more than 26,000 sharks (GSAFDF, 1998).

The NMFS Biological Opinion requires observer coverage in some fisheries to avoid jeopardy to animals that are protected under the Endangered Species Act. Five percent coverage of the pelagic longline fishery is required and a final recommendation of the Atlantic Large Whale Take Reduction Team was to increase observer coverage in this fishery, which would provide more accurate data on levels of protected species bycatch. In addition, the Biological Opinion requires NMFS to provide observers with complete sampling kits and protocols to maximize data collection opportunities, especially with regard to analyzing the relative proportion of loggerheads taken from the northern subpopulation. The Biological Opinion also requires 100 percent observer coverage of the shark drift gillnet fleet during right whale season.

Vessel Monitoring Systems

In 1997, ICCAT recommended that nations implement a vessel monitoring system (VMS) program to track the fishing positions of their larger commercial vessels fishing for HMS by 1999. This FMP goes a step further to implement a VMS program for all U.S. pelagic longline vessels. The VMS program will support efforts to enforce time/area closures. In the past, NMFS had a voluntary VMS pilot program that allowed vessels to offload swordfish after the directed fishery closure so long as they ceased fishing by the time of the closure. The new VMS initiative will also allow NMFS to track a more accurate geographic distribution of pelagic longline fishing effort. In addition to providing an opportunity for real time monitoring, and delayed off-loading and/or transit during directed fishery closures, VMS will promote safety-at-sea and communication for participating vessels. In the future, VMS may be used to collect near real-time catch and effort data, as well as bycatch data reported by observers.

2.6.2 Monitoring and Reporting in the Recreational Fishery

By definition, recreational landings of Atlantic HMS are those that are not marketed through commercial channels, therefore it is not possible to monitor anglers' catches through ex-vessel transactions as in the commercial fishery. Instead, NMFS conducts statistical sampling surveys of the recreational fisheries. These survey programs have been used for well over a decade. The two primary survey vehicles of the recreational sector conducted by NMFS are the Marine Recreational Fishing Statistics Survey (MRFSS) and the Large Pelagic Survey. Estimates of U.S. recreational harvests for tuna and tuna-like species are currently under active review as described in the 1998 U.S. National Report to ICCAT (October, 1998).

The MRFSS is a survey designed to provide regional and state-wide estimates of recreational catch for marine fish species in the Atlantic. It was not designed to account for the unique characteristics of HMS fisheries, although information on these species is frequently obtained by the survey. The MRFSS is a random-dial telephone survey, restricted to coastal counties from Virginia through Louisiana. The MRFSS does not cover the state of Texas nor does it cover the charter/headboat fisheries. Therefore, data from the charter/headboat sector of the fishery are provided by an independent survey in the State of Texas and by the NMFS Headboat Survey in the southeast United States. Information collected by the MRFSS on recreational shark landings is used to estimate the number of fishing trips, the number and species of sharks caught and/or landed, the weight of these sharks, and the number of persons fishing. Shark species are identified to the extent possible.

The MRFSS estimates three types of catch:

1. Fish that are available for identification, enumeration, weighing, and measuring by dockside interviewers are called Type A catch or *landings*;

2. Fish not brought ashore in whole form but used as bait, filleted, or discarded dead are called Type B1 catch (Type A and Type B1 catch together comprise *harvest*);

3. Fish released alive are called Type B2 catch; and

4. The sum of Catch Type A, Catch Type B1, and Catch Type B2 is called *total catch*.

The MRFSS estimates of recreational landings and harvest are calculated using Type A and B1 catches only. Estimates of Type B2 catches were not included. Thus, estimates of “catch” are actually estimates of immediate recreational fishing mortality as landings or harvest. A complete accounting of fishing mortality would include post-release mortality associated with Type B2 fish. Quantitative estimates of post-release or delayed mortality of HMS in recreational fisheries are not available at this time.

The Large Pelagic Survey was originally designed to estimate annual recreational catches of bluefin tuna from North Carolina through Massachusetts in the summer months (primarily for small and medium bluefin tuna) and to evaluate abundance trends of bluefin tuna by monitoring catch and effort associated with all sizes of bluefin tuna. Although it was designed for bluefin tuna, the Large Pelagic Survey collects catch information on other highly migratory species at certain times and in certain areas. There are two phases to this survey: 1) dockside interviews and observation to obtain number, species, and sizes of fish caught during a trip; and 2) a telephone survey directed at those people likely to be active in the HMS fishery to obtain the amount of effort during the prior reporting period and corroborative information about the number of fish captured. In 1992, the Large Pelagic Survey was redesigned to provide inseason monitoring of recreational catches of bluefin tuna relative to the quota. This was done by increasing the frequency of the reporting period, increasing both dockside and telephone sampling frequency, expanding the areas and times of monitoring, and focusing the sampling in the times and areas most important for the bluefin tuna catch estimation. Although the Large Pelagic Survey was designed for bluefin tuna, the data are also used to estimate catch information for other HMS and to monitor catch per unit effort trends.

In 1997, NMFS instituted a mandatory Automated Catch Reporting System to supplement monitoring of the recreational fishery for Atlantic bluefin tuna. Although this call-in requirement (1-888-USA-TUNA) is an integral part of the Angling category monitoring system, it has not replaced traditional survey methods in the recreational fishery. The recreational surveys described above are conducted simultaneously in order to provide a measure of comparison for the reported catch estimates. All vessels landing bluefin tuna against the Angling category quota are required to participate in both the call-in reporting and survey programs. NMFS will continue to examine the results from these quota monitoring approaches together to enhance the accuracy and timeliness of quota monitoring in the Angling category for bluefin tuna.

A NMFS pilot program includes a telephone survey of charterboat fishing effort in Louisiana, Mississippi, Alabama and the Florida Gulf Coast, which is being conducted in cooperation with the Gulf States Marine Fisheries Commission, the Alabama Department of Conservation and Natural Resources, the Florida Department of Environmental Protection, the Louisiana Department of Wildlife and Fisheries, and the Mississippi Department of Marine Resources. The NMFS Panama City Laboratory has also conducted a pilot logbook panel survey of charterboat fishing effort along the Florida panhandle. These pilot programs are being tested as alternative methods for estimating charterboat fishing effort already covered by the MRFSS. The pilot surveys are currently being evaluated in comparison with the current MRFSS method to determine which method is best for estimating charterboat fishing effort. Although this FMP establishes a mandatory logbook reporting requirement for charter/headboat vessels, the pilot program is investigating alternate means of obtaining accurate catch estimates in this fishery, while minimizing survey costs and the reporting burden.

NMFS is committed to working with the states to develop more effective partnerships for monitoring the recreational fisheries. As part of a program launched in 1998, more than 25 reporting stations have been established in North Carolina, and Angling category vessel operators in the winter fishery are required to fill out a catch reporting card for each bluefin tuna. Information on these angler catch cards is entered into a database in the Northeast Regional Office on a weekly basis. This program, coordinated by NMFS in cooperation with the North Carolina Division of Marine Fisheries, was continued in 1999. Other mid-Atlantic states, including Maryland, Delaware, and Virginia have demonstrated an interest in establishing a similar program. There are significant challenges associated with developing tagging programs for the recreational fishery, since the participants are widely dispersed and recreational landings are not channeled through any central points of contact (e.g., fish dealers in the commercial fishery). NMFS believes that a successful tagging program depends upon effective state and federal coordination that takes into account regional differences in the fishery, in addition to cooperation with the recreational industry.

In April 1998, NMFS implemented a mandatory registration system for tournaments involving any billfish, with mandatory reporting if selected. This FMP extends the requirement to tournaments directed at any Atlantic HMS, in order to improve estimates of HMS catches and landings by tournament participants. Tournament registration allows NMFS to establish a universe in order to expedite outreach to recreational fishermen who participate in tournaments. The reporting forms also provide NMFS with catch, release, and fishing effort statistics that are useful in characterizing the fishery. Because the Large Pelagic Survey does not collect recreational fishing data in the southeast United States or the Gulf of Mexico, tournament data can provide information on which species are targeted in these areas, as well as release rates for each species. Finally, this information allows NMFS scientists to travel to selected tournaments to collect data on age/growth and sexual maturity that are used in stock assessments.

2.6.3 Other Data Collection Programs

Tagging

Tagging studies are used primarily to determine the distribution, migration paths, growth rates and rates of movement of HMS. These factors relate directly to the key management issues of stock identification and stock productivity. When a tagged fish is recaptured, the location, size, and other biological characteristics are assessed as compared to conditions when the fish was released. This has proven to be a cost-effective and reliable means of gathering information that can provide the basis for determining the growth and movement of HMS. To date, tag returns have demonstrated the existence of trans-Atlantic migrations, but most HMS are reported recaptured on the same side of the Atlantic.

All release and recapture data collected by the Southeast Fisheries Science Center's Cooperative Tagging Center (CTC) are made available to ICCAT. The CTC is a continuing joint research effort by scientists and recreational and commercial fishermen that is designed to provide information on the movements and biology of HMS through the direct participation of the public. NMFS has established Internet access for communication between the CTC database and other agencies or countries. This will facilitate high-speed transfer of tagging data to and from other tagging programs, with the intent to establish the CTC as the central depository for HMS release and recapture information. In the eastern Atlantic and Mediterranean Sea, an ICCAT tag recovery program was established in 1997, with coordinators appointed for key geographic locations throughout the area.

Fishermen and scientists working with the CTC released more than 2,400 bluefin tuna with conventional tags during 1997. As of August 1997, at least 183 of the bluefin tuna released near Hatteras had been recaptured from off the western North Atlantic and an additional six were recaptured in the eastern Atlantic and Mediterranean. The number of swordfish tagged and released by U.S. pelagic longline vessels has substantially increased since the United States implemented minimum size regulations in 1991, now averaging about 1,200 fish annually. Reported recoveries of tagged swordfish have likewise increased.

The National Marine Fisheries Service conducts an extensive Cooperative Shark Tagging Program (CSTP) using volunteer assistance of recreational and commercial fishermen. Fishermen catch sharks primarily on rod and reel, on private vessels and charterboats, at sport fishing tournaments and on longline gear aboard research vessels and commercial fishing vessels. In 1997, members of the Cooperative Shark Tagging Program tagged 8,816 fish representing 31 species of sharks and rays and 11 species of teleosts. This is the second highest number tagged in a single year (second only to 1996) and brings the total to more than 147,000. U.S. fishermen, in conjunction with fishermen from England, Canada, Portugal, Ireland, France, and Spain were responsible for the tagging effort. Recreational anglers tagged 68 percent of sharks, fishing with rod and reel and tagging free swimming sharks, while NMFS and other biologists tagged 21 percent using longline, gill nets, and handlines. Commercial fishermen and observers on board commercial vessels tagged an additional 1,016 fish (11 percent).

Shark tagging studies, in cooperation with Mote Marine Laboratory's Center for Shark Research, have been underway since 1991. Primarily juvenile and small adult sharks have been tagged in a number of coastal areas of the Gulf of Mexico, including off Florida, Texas, and Mexico. An intensive tagging study has been underway since 1995 in Quintana Roo, Mexico, in cooperation with Mote Marine Laboratory and Mexico's Instituto Nacional de la Pesca. These various studies are designed to map shark nursery areas and migratory patterns, assess age and growth characteristics, assist with stock identification, and evaluate the degree of exchange of shark stocks across international boundaries.

Recently, tagging technology has progressed to create fish tags equipped with small computers that can store information on changes in location and temperature for years at a time. Although these archival tags are costly, the information content of a single tag is much greater than that associated with traditional tagging methods. The ability to trace the migration of an individual fish may lead to better determinations of stock units for HMS management. In the future, these high-technology archival tags may provide definitive information on bluefin tuna spawning site fidelity in the western Atlantic and Mediterranean Sea, indicating whether bluefin tuna that swim across the ocean actually return to spawn in the area where they originated or spawn in multiple areas. Archival tags also facilitate behavioral studies that investigate the physiological and environmental preferences of HMS.

In recent years, programs involving non-traditional tagging, including pop-up and archival satellite tags, have been gaining momentum. The catch and release winter fishery for medium and large bluefin tuna in North Carolina provides a good setting for conducting research on archival tagging. As of March 1999, ten bluefin tuna with archival tags have been recovered, two in the Mediterranean, two in Canada and six along the Atlantic coast of the United States, and information has been retrieved via satellite from 42 of the pop-up satellite tags. Preliminary findings of this research have been published in the Proceedings of the National Academy of Science. In the early months of 1999, researchers off the coast of North Carolina placed 100 additional archival tags in mature bluefin tuna weighing between 350 and 600 lbs. Nine more pop-off satellite tags have been placed on the mature bluefin, six off the Carolinas, and three in the Gulf of Mexico off Louisiana. These tags are programmed to pop-off before September 1999. Tagging of medium and giant bluefin tuna will continue to improve the documentation of year class differences in movement patterns, definition of geographical boundaries, and investigation of potential overlap of Atlantic bluefin tuna stocks. This research is designed to identify any patterns of movement that might indicate spawning versus feeding grounds based on geolocation, temporal visitation, and temperature data. Possible correlations between the movement patterns of bluefin tuna and oceanic features such as temperature and currents will also be examined over long time periods.

As part of the comprehensive plan for HMS monitoring and research, NMFS scientists will enhance cooperative partnerships to develop new systems that optimize the release and recapture of tagged HMS. Future research sponsored by the agency is likely to include tag performance experiments, improved tag and attachment anchor design, and modification of reporting protocols to improve recapture information. In addition to their important implications for stock structure, new tagging technology and field and laboratory experiments will provide NMFS with additional data to support the estimation of HMS life history parameters. These improved tagging efforts will also be useful in future investiga-tions of post-release survival rates for HMS in both commercial and recreational fisheries.

Cooperative Agreements with States

In order to facilitate the collection of fisheries data, NMFS has established cooperative agreements with many of the Atlantic and Gulf of Mexico coastal states, Puerto Rico, and the U.S. Virgin Islands to collect fishery statistics. The cooperative agreements do not impose a specific method of data collection for the landings statistics. The states have implemented various procedures that are consistent with their management and regulatory needs to collect these data. The states, however, are bound to provide the landings data as monthly summaries by species by dealer with the county where the product was landed and the area where it was caught. The states are obligated to provide these data within 60 days from the end of each calendar month.

A number of states are expanding their data collection programs to include tagging of HMS. Cooperation with state agencies, universities and constituents, within the various states, on tagging of HMS is opportunistic and varies from year to year. Shark tagging is often carried out through the states under contracts to investigate early life history stages and inshore fishing effort on the smaller sharks. The tagging effort coordinated by NMFS for bluefin tuna and billfish requires a special tagging kit (50 CFR Ch.II; 285.27). Several state agents, and U.S. Coast Guard personnel are aware of this requirement and assist in the distribution of tagging kits from time to time.

Databases to Support Management Decisions

The information collected by NMFS and other entities on HMS is stored in numerous databases. The majority of the information collected, including data on catch and effort, discards, tagging programs, ex-vessel prices, exports and imports, biological sampling, and observer programs, is stored in databases maintained by NMFS at Headquarters and the Northeast and Southeast Fisheries Science Centers and Regional Offices. The Regional Offices and Headquarters also maintain databases on vessels and dealers permitted to participate in HMS fisheries. Currently, an effort is underway within NMFS to document all existing databases, including those maintained outside the agency, that contain information on HMS.

Section 401 of the Magnuson-Stevens Act requires the Secretary of Commerce to work with key stakeholders to develop a proposal for implementing a nationwide fishing vessel registration system and fisheries information collection system. This system will integrate all fishery-dependent data systems required under applicable federal statutes and regulations. One of the primary objectives is to reduce the burden on fishermen and other industry participants who collect fisheries data. Existing programs, systems and infrastructure investments will be utilized to the extent possible.

While the comprehensive fisheries information and vessel registration systems will be coordinated across regions, they will also be designed to recognize the unique characteristics of regional fisheries. The new systems should improve NMFS' ability to aggregate harvest data into national summary-level data. Multiple, independent regional information management systems that currently lack a common or overarching framework will soon be linked. The Atlantic Coastal Cooperative Statistics Program (ACCSP), a cooperative state-federal program designed to improve the collection and management of marine and coastal fisheries data, is implementing a pilot information management system and other regions are engaged in similar strategic planning. The mission of the ACCSP is to cooperatively collect, manage, and disseminate fishery statistical data and information for the conservation and management of fishery resources for the Atlantic coast and to support the development and operation of a national program. Information on the ACCSP program was provided to a joint session of the HMS Advisory Panel and Billfish Advisory Panel.

The recently established Core Statistics Program at NMFS has also played a significant role in shaping the fisheries information proposal and will continue to be an integral component of the comprehensive system. The fisheries information initiative will seek to establish data quality standards for accuracy and timeliness that are acceptable to all data providers and information managers. The NMFS Division of Fishery Statistics and Economics already maintains several databases that contain information on the value and volume of U.S. commercial landings, wholesale prices, and trade data. Future surveys will improve the collection of information on the costs and earnings of commercial and recreational fishing vessels. These data are important for making allocation decisions and for understanding the consequences of management alternatives on the fishing industry. NMFS believes that the new system will build public confidence in the agency's ability to collect fisheries information in the most efficient and effective manner possible.

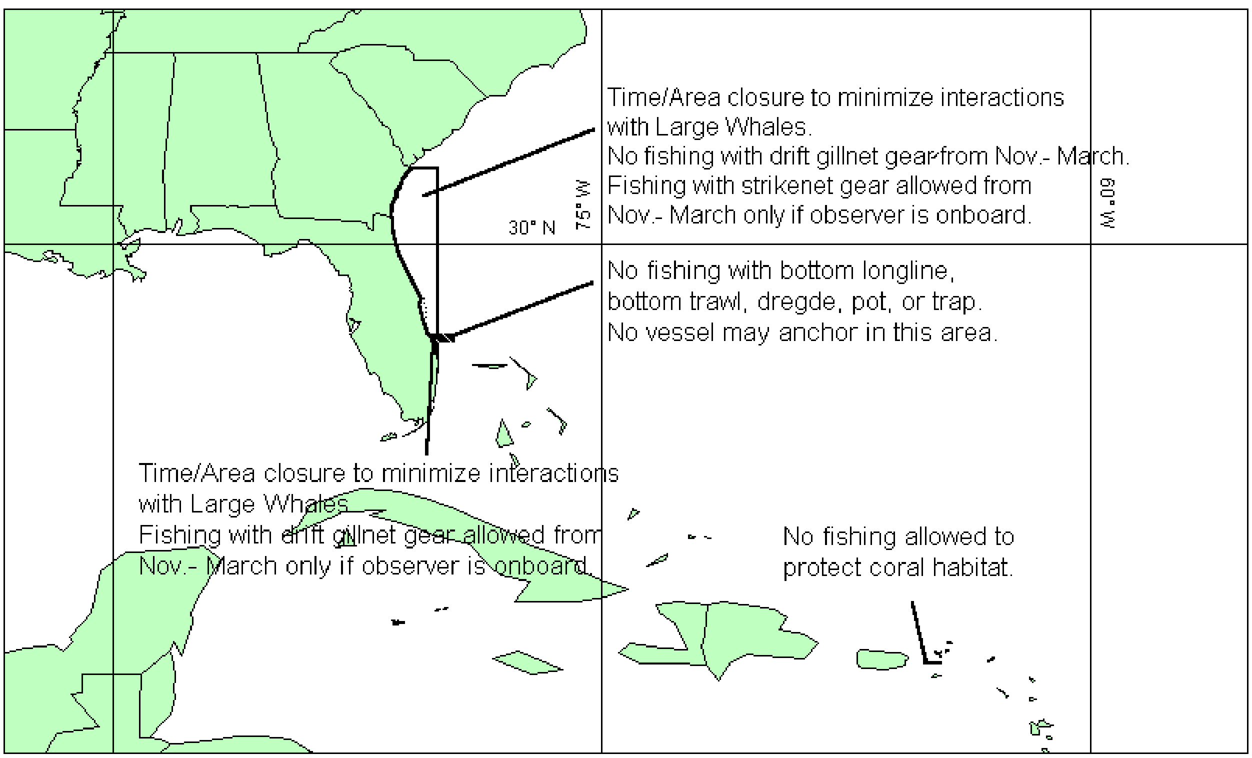
Table 2.51 HMS permitting and reporting requirements.

Species	Vessels	Dealers/Importers/Tournaments
Bluefin	Landing cards At-sea observer (if selected) Logbooks (if selected) LPS/MRFSS (recreational: if contacted) Phone-in report (1-800-USATUNA) Permits: Angling General Longline Purse seine HMS Charter/Headboat Trap	Landing cards Biweekly dealer report Biweekly importer report ICCAT BSD Tournament registration and reporting Permits for Dealers and Importers
Other Tuna	At-sea observer (if selected) Logbooks (if selected) LPS/MRFSS (recreational: if contacted) Permits: Angling General Longline Purse seine HMS Charter/Headboat Trap	Biweekly dealer report Tournament registration and reporting Permits for Dealers
Sharks	At-sea observer (if selected) Logbooks (if selected) LPS/MRFSS (recreational: if contacted) Permits: Directed Incidental HMS Charter/Headboat	Biweekly dealer report Tournament registration and reporting Permits for Dealers
Swordfish	At-sea observer (if selected) Logbooks (if selected) Trip summaries Set forms Tally sheets LPS/MRFSS (recreational: if contacted) Permits: Directed (Longline) Directed (Handgear) Incidental HMS Charter/Headboat	Biweekly dealer/import report Tournament registration and reporting Permits for Dealers/Importers Certificate of Eligibility for imports

2.7 Existing Time/Area Closures under MMPA and Other Laws

In addition to the time/area closure implemented in this FMP (see Section 3.5), there are a number of time/area closures implemented by NMFS, states, or the Councils which may affect the way HMS fishermen fish. These include time/area closures to protect large whales or coral habitat. Some of these time/area closures are shown in Figure 2.6 below. Each closure affects different gear types, lasts for different lengths of time, and may have observer requirements. Highly migratory species fishermen who fish in these areas must follow these regulations as well as the regulations outlined in this FMP. For a complete understanding of the regulations shown in the figure below, HMS fishermen should refer to 64 FR 7529 (Large Whale Take Reduction Plan) and 50 CFR 622.35 (c) (Oculina Banks). The Caribbean Coral Reef Plan time/area closure is entering the proposed rule stage and is not final at this time. Because HMS cover the Atlantic and the Gulf of Mexico, HMS fishermen should be sure to contact their Regional Office or Council in order to keep apprised of any change in regulations outside of HMS which may affect them.

Figure 2.6 Map showing locations of time/area closures which may affect HMS fishermen. Summaries of the regulations are also shown. The Caribbean Coral Reef time/area closure is not final at this time.



References Cited in Chapter 2

Anonymous. 1995. 1995 Atlantic Management Plan: Porbeagle, Shortfin Mako, and Blue Sharks. Department of Fisheries and Oceans, Canada.

Babcock, E.A. and E.K. Pikitch.1998. The effect of bag limits on shark mortality in the U.S. Atlantic recreational fishery. Shark Evaluation Workshop document SB-IV-25. 32 pp.

Beideman, N. 1998. Blue Water Fishermen's Association, Barnegat Light, NJ, Personal communication.

Berkeley, S.A., E.W. Irby, Jr., and J.W. Jolley, Jr. 1981. Florida's Commercial Swordfish Fishery: Longline Gear and Methods. MAP-14, Marine Advisory Bulletin, Florida Sea Grant College in cooperation with University of Miami, Rosenstiel School of Marine and Atmospheric Science and Florida Department of Natural Resources, Florida Cooperative Extension Service, University of Florida, Gainesville, FL, 23 pp.

Bonfil, R. 1997. Status of Shark Resources in the Southern Gulf of Mexico and Caribbean: Implications for Management. Fisheries Research 29: 101-117.

Brown, C.A. and S.H. Gruber. 1988. Age Assessment of the Lemon Shark, Negaprion Brevirostris, Using Tetracycline Validated Vertebral Centra. Copeia 1988: 747-753.

Carroll, M.T. 1998. An Assessment of the Atlantic Bluefin Tuna Market: Implications for Management. University of Rhode Island Master's Thesis. Kingston, RI. 212 pp.

Casey, J.G., H.L. Pratt, C.E. Stillwell. 1985. Age and Growth of the Sandbar Shark, Carcharhinus Plumbeus, from the Western North Atlantic. Can. J. Fish. Aquat. Sci. 42: 963-975.

Castillo, J.L. and J.F. Marquez. 1996. Evaluacion de la Pesqueria de Tiburon del Golfo de Mexico. Instituto Nacional de la Pesca, Secretaria de Pesca. 198 pp.

Castillo, J.L., J.F. Marquez. M.C. Rodriguez, E. Cortes, and A. Cid. 1998. The Mexican artisanal shark fishery in the Gulf of Mexico: toward a regulated fishery. 1998 SEW Document, SB-IV-8. 39 pp.

Castro, J.I. 1983. The Sharks of North American Waters, College Station, TX: Texas A & M University Press, 180 pp.

CITES. 1996. Discussion Paper Pursuant to CITES Resolution Conf. 9.17: An Overview of the Impacts on the Biological Status of Sharks, 66 pp.

Cramer, J., and H. Adams. 1998. Large Pelagic Logbook Newsletter - 1996, NOAA Techical Memo. NMFS-SEFSC-407, p. 61.

Cramer, J. and G.P. Scott.1998. Summarization of catch and effort in the pelagic longline fishery and analysis of the effect of two degree square closures on swordfish landings and discards, Sustainable Fisheries Division Contribution MIA-97/98-17.

Cramer, J. 1996. Species Reported Caught in the U.S. Commercial Pelagic Longline, Gillnet, and Pair Trawl Fisheries from 1987 to 1995, Miami Lab. Contribution MIA- 95/96-38, 91 pp.

FAO. 1997. Food and Agriculture (FAO) Yearbook, Fisheries statistics, commodities. Food and Agriculture Organization of the United Nations, Rome.

Fisher, M.R. and R.B. Ditton. 1992. Characteristics of Billfish Anglers in the U.S. Atlantic Ocean, Mar. Fish. Rev. 54, 6 pp.

Folsom, W.B., D. M. Crory, and K. Brewster-Geisz. North America-Swordfish Fishing. Published in "World Swordfish Fishing: An Analysis of Swordfish Fishing Operations. Past-Present-Future. Volume IV. "Prepared by the Office of Science and Technology, National Marine Fisheries Service, NOAA., US Department of Commerce, Silver Spring.

Gulf and South Atlantic Fisheries Development Foundation, Inc. 1997. Continuation of an observer program to characterize and compare the directed commercial shark fishery in the eastern Gulf of Mexico and South Atlantic, MARFIN Grant No. NA57FF0286, May 1997.

Gulf and South Atlantic Fisheries Development Foundation, Inc. 1996. Characterization and comparisons of the directed commercial shark fishery in the eastern Gulf of Mexico and off North Carolina through an observer program. Final Report. MARFIN Grant No. NA47FF0008. 74 pp.

Helfman, G.S., B.B. Collette, and D.E. Facey. 1997. *The Diversity of Fishes*. Blackwell Science, Inc. Malden, MA. 528 pp.

Hurley, P.C.F. 1998. A review of the fishery for pelagic sharks in Atlantic Canada. Fisheries Research 39: 107-113.

Lucy, J.A., E.A. Bochenek, and N.J. Chartier. 1990. Fleet Characteristics and Boat-Owner Expenditures Associated with Virginia's Recreational Marline-Tuna Fishery. In Planning the Future of Billfishes Part 2 253-262. National Coalition for Marine Conservation.

McHugh, R.J. and T.J. Murray. 1997. An analysis of the demand for, and supply of shark. MARFIN Grant No,. NA57FF0052, University of South Florida and Georgia State University, December 1997.

Moyle, P.B., and J.J. Cech. 1996. *Fishes: an Introduction to Ichthyology*, 3rd Edition. Prentis Hall. Upper Saddle River, NJ. 590 p.

NMFS. 1998a. Permits Division, St. Petersburg, FL, personal communication. May 3, 1998.

NMFS. 1998b. Proposed Amendment 1 to the Atlantic Billfish Fishery Management Plan, October 1998.

NMFS. 1998c. Consideration of the Economic Effects and Potential Alternatives to the 1997 Quotas on the Atlantic Large Coastal Shark Fishery. May 14, 1998. p 52.

NMFS. 1997a. National Report of the United States: 1997. ICCAT Working Document SCRS/97/Revised (11/4/97), November 1997.

NMFS. 1997b. 1997 Shark Evaluation Annual Report. Southeast Fisheries Science Center. 11pp.

NMFS. 1997c. Southern New England Bonito and Little Tunny Fishery Exemption Area incorporating the Environmental Assessment: Northeast Multispecies Fishery Management Plan, NMFS, Northeast regional office, May 28, 1996 and Addendum to the Environmental Assessment for the Southern New England Little Tunny Gillnet Fishery.

NMFS. 1997d. 1994/1995 Report of the Southeast Fisheries Science Center Billfish Program. NOAA Technical Memorandum NMFS-SEFSC-398, 15 p.

National Research Council. 1994. An Assessment of Atlantic Bluefin Tuna. National Academy Press. Washington, D.C., 144 pp.

Ofiara, D. and B. Brown. 1987. The 1986 Economic Survey of New Jersey's Big Game Fishery. New Jersey Department of Environmental Protection, Division of Fish, Game and Wildlife, Marine Fisheries Administration, Technical Series 87-1, 21pp.

Rose, D. A. 1996. An overview of world trade in sharks and other cartilaginous fishes. TRAFFIC International. 106 pp.

South Atlantic Fishery Management Council (SAFMC). 1985. Fishery Management Plan, Regulatory Impact Review, Initial Regulatory Flexibility Analysis, and Final Environmental Impact Statement for Atlantic Swordfish. Southpark Circle, Suite 306, Charleston, South Carolina, February, 1985.

SAFMC. 1990. Amendment 1 to the Fishery Management Plan for Atlantic Swordfish, Charleston, SC, October 1990, 101 pp.

SCRS. 1990. Field Manual for Statistics and Sampling Atlantic Tunas and Tuna-Like Fishes, 3rd edition, ICCAT, Madrid, Spain, 184 pp.

Scott, G.P., P.J. Phares, and B. Slater. 1996. Recreational Catch, Average Size and Effort Information for Sharks in U.S. Atlantic and Gulf of Mexico Waters. Southeast Fisheries Science Center. NMFS. Miami lab. Contribution ML-95/96- 44. 1996 SEW Document, SBIII-5., p 56.

Sona, S.C. 1998. Shark fisheries, trade, and market of Japan. NOAA Technical Memoramdum NMFS. NOAA-TM-NMFS-SWR-033.

Taylor, T., C. Adams, and J. Roderick. 1995. Economic Effects of Swordfish Management Policy on Swordfish and Tuna Fisheries in the Gulf of Mexico. Draft Final MARFIN Project Report, MARFIN Project Number NA-37FF0055, Food and Resource Economics Department, Inst. of Food and Agr. Sci., U of Florida, Gainesville, FL.

Thunberg, E. and J.L. Seale. 1992. Economic Analysis of United States Demand for Swordfish and Economic Effects of Effort Reduction on the Gulf of Mexico Swordfish Fishery. Final Project Report, MARFIN, Department of Food and Resource Economics, P.O. Box 110240, U of Florida, Gainesville, FL.

Trent, L., D.E. Parshley, and J.K. Carlson. 1997. Catch and Bycatch in the Shark Drift Gillnet Fishery Off Georgia an East Florida. Marine Fisheries Review 59(1): 19-28.

Turner, R.E., and D.F. Boesch. 1987. Aquatic animal production and wetland relationships: Insights gleaned following wetland loss or gain. *In:* D. Hooks (eds.), Ecology and Management of Wetlands: 25-39. Croon Helms, LTD, Beckenham, Kent, UK.

Watson, E. 1996. An Economic Comparison of the U.S. and Canadian Atlantic Bluefin Tuna Fisheries. Thesis, University of Maine. Orono, Maine.

Weber, M.L. and S.V. Fordham. 1997. Managing Shark Fisheries: Opportunities for International Conservation. TRAFFIC International ad the Center for Marine Conservation. 61 pp.

Wilson, D., B.J. McCay, D. Estler, M. Perez-Lugo, J. LaMarque, S. Seminski, A. Tomczuk. 1998. Social and Cultural Impact Assessment of the Highly Migratory Species Fishery Management Plan and the Amendment to the Atlantic Billfish Fisheries Management Plan, NOAA-NMFS-HMS Contract 178 pp.